# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

**JUNE 1915.**

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# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

### JUNE 1915.

## GENERAL PHYSICS.

**623.** *Principle of an Electrical Machine for Solving Numerical Equations of any Degree.* **J. Bethenod.** (Lum. Élec. 29. pp. 25-26, April 10, 1915.)—It is proposed to utilise the following principle to construct apparatus for solving equations: With suitable construction a dynamo machine may be made to develop an e.m.f. proportional to the velocity of rotation $\omega$. Applying this e.m.f. to a circuit of constant resistance, a current $i_1$ is obtained. The whole or a fraction of this current can then be used to excite the field of a second machine of suitable type, which will produce an e.m.f. proportional to $\omega i_1$, *i.e.* to $\omega^2$, and so a current $i_2$ can be obtained in a circuit of constant resistance, proportional to $\omega^2$. This process can be repeated, and thus a system of $n$ currents can be obtained proportional respectively to $\omega, \omega^2, \omega^3 \dots \omega^n$. Completing the system by the addition of a constant current $i_0$, a galvanometric apparatus acted on by these $(n + 1)$ currents will indicate when the algebraic sum is zero. If such an equilibrium is attained we have $O = i_0 + k_1\omega + k_2\omega^2 + \dots + k_n\omega^n$, where $k_1 k_2 \dots k_n$ are constants depending on the construction of the machines and on the different circuits. If then the velocity of rotation of the machines is increased, the galvanometric apparatus will be in equilibrium each time that $\omega$ reaches a value equal to one of the $n$ roots of the above equation. A. W.

**624.** *New Hydrometer of Total Immersion with Electromagnetic Compensation.* **A. Ångström.** (Phys. Rev. 5. pp. 249-265, March, 1915.)—The present paper contains an account of a new method for determining the specific gravity of liquids and especially the specific gravity of sea-water, from which the salinity may be calculated with high degree of accuracy. Nansen's conclusions from a study of the errors and irregularities attaching to floating hydrometers are referred to, and the remark is made that several eminent oceanographers are inclined to discard the floating hydrometer as unsuitable for accurate work. To avoid errors arising from variations in surface-tension, methods with hydrometers of total immersion have been invented, these being primarily of two kinds—namely: (1) where the hydrometer itself through the adding of small loads is brought to the point where it just sinks down totally in the liquid, and (2) where the specific gravity of the liquid is changed in order to attain the same end. Nansen's method combines these two principles, very small density-changes being produced by raising or lowering the liquid temperature with a thin Pt-spiral electrically heated. These methods have the inconvenience of requiring a considerable amount of time and trouble for each determination. A method almost exclusively used by the international organisation for the study of the North Sea is to determine by titration the amount of chlorine contained in the sea-water. From the amount of chlorine, the salinity as well as the density at different temperatures can be found from Knudsen's hydrographic tables.

The present author has designed a hydrometer of total immersion worked by electromagnetic compensation, *i.e.* counterbalancing the buoyancy of a float completely immersed in sea-water by an electromagnetic force acting on a piece of soft iron within the float. A full description with illustrations is given of the apparatus. A curve is given showing the sensibility of the instrument, and an accuracy is claimed equal to that of the chemical method. H. H. Ho.

**625.** *Harmonic Analysis.* **A. Russell.** (Nature, 95. p. 204, April 22, 1915.)—This letter is in support of a previous suggestion that the best way of analysing a wave, the graph of which is given, is to apply the rules for the mechanical quadrature of integrals, which are given in treatises in the calculus of finite differences. The case is taken of applying Weddle's rule to a semicircular alternating wave, where the evaluation of the Fourier integrals for it by analysis is particularly laborious. From the practical point of view it is demonstrated that the simplicity and accuracy of the method leaves little to be desired, while there is the great advantage of being able to compute the amplitude of each harmonic independently of the others. When the wave passes smoothly through the extremities of the ordinates the rule may be applied with confidence, but jagged or very distorted waves must be treated more carefully. H. H. Ho.

**626.** *Determination of Latitude, Azimuth, and Length of Day.* **A. H. Compton.** (Phys. Rev. 5. pp. 109–117, Feb., 1915.)—A method is outlined whereby the components of the earth's rotation about two mutually perpendicular horizontal axes may be determined mechanically. The measurements are made on small globules of oil in water contained in a brass tube bent into a ring fitted with an axis in its plane, so that the ring may be quickly reversed through 180°. In general, one side of the tube will be moving with respect to the other side on account of the earth's rotation, and on reversal the heat of the tube on one side of the axis will have its motion changed as it is shifted to the other side, while the liquid inside retains a large part of its original motion. Special precautions were taken to minimise the interference by convection currents due to temperature variations. The results obtained show a comparatively low degree of accuracy, and their chief interest lies in their being independent of astronomical observations. [See also Abs. 1257 (1913).] C. P. B.

**627.** *Application of Instantaneous Photography to the Measurement of the Differences of Longitude.* **G. Lippmann.** (Journ. de Physique, 4. pp. 445–449, June, 1914.)—The author proposes to simplify the ordinary mode of procedure by utilising Hertzian waves from a station such as that at the Eiffel

Tower. The collimator fixed on a pillar is furnished with a silvered glass on which is traced with a diamond a minute transparent cross. The parallel rays emanating from the centre of this cross are reflected by a transparent glass fixed to the same pillar and are received in the photographic apparatus. The glass being transparent, the heavens and the little cross are photographed at one and the same time. The vertical adjustments are secured by the use of a mercury bath and regulating screw acting micrometrically upon the silvered plate.

It is necessary that the artificial stars which are fixed in the two zeniths shall be lighted instantaneously and shall appear simultaneously in the two zeniths. Each little cross is therefore illuminated by an electric spark, and matters are so arranged that the spark shall pass just at the moment when the Hertzian wave arrives. A motor makes one turn per sec. and carries an adjustable commutator. Coincidence between the arrival of the wave and the passage of a spark is secured by listening to a telephone and at the same time varying the adjustment of the contact-maker. A precision of a hundredth of a second can be thus obtained. E. O. W.

628. *Compressibilities of Mercury, Copper, Lead, Molybdenum, Tantalum, Tungsten, and Silver Bromide.* **T. W. Richards** and **E. P. Bartlett.** (Am. Chem. Soc., J. 37. pp. 470–481, March, 1915.)—The authors have determined the compressibilities of the above substances, employing a steel piezometer. The hysteresis of glass under high pressure is thereby avoided. The results now obtained confirm the accuracy of the former ones, and the difference in the final values of the compressibilities is due chiefly to a change in the assumed compressibility of mercury, which is now referred to a new absolute value for iron ($0·61 \times 10^{-6}$). The compressibilities of the various substances at 20° (expressed in the megabar standard, multiplied by a million) are as follows: Copper, 0·76; lead, 2·35; mercury, 3·96; molybdenum, 0·47; tantalum, 0·54; tungsten, 0·28; silver bromide, 2·70. In each case the range of pressure was between 100 and 500 megabars. The outcome is as consistent as could be expected with the work of Bridgman and Grüneisen, and previous discrepancies are explained. Especial attention is called to the very small compressibility of tungsten. [See Abs. 441 (1911).] A. F.

629. *Elasticity of Curved Cylindrical Bodies.* **T. Matsumura.** (Kyōto Coll. Eng., Mem. 1. 2. pp. 59–85, Feb., 1915.)—A mathematical discussion (which cannot be usefully abstracted) of the theory of elasticity of curved cylindrical bodies with particular applications to the determination of the change of form produced in a cylindrical and in a conical spring by the action of axial forces. J. W. T. W.

630. *General Expression for Stress-components in Two-dimensional Problems of Elasticity.* **S. Yokota.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 38–50, Feb., 1915.)—Chiefly mathematical and cannot be usefully abstracted. The examples given include the determination of the stress distribution in a plate with a circular hole. It is concluded that, for such a plate subjected to a constant tension $y$ at infinity, the max. tangential tension at the periphery of the hole is $3y$, whether the hole be open or filled with a circular plug of the same material as the plate and of any degree of tightness up to an initial radial pressure of $5y/4$. This agrees with Coker's experimental results. J. W. T. W.

**631.** *Elastic Properties of Steel at Moderately High Temperatures.* **F. E. Rowett.** (Roy. Soc., Proc. 91. pp. 291–302, April 1, 1915.)—Describes experiments on the elastic hysteresis of steel tubes, both hard-drawn and annealed, at temperatures lying between 300° and 540° C. At the lower of these temperatures the hard-drawn tube began to behave as a viscous fluid, being still highly elastic under rapidly varying stress, but showing perceptible flow under a stress applied for a long time. The energy lost during the performance of a cycle of stress was found, therefore, to vary with the speed of the cycle, being much the same as at ordinary room temperatures when the cycle was performed in 5 secs., but rising to four times this amount if the period was increased to 15 mins. The annealed tube at the same temperature showed no such effect, the energy dissipated per cycle of stress remaining almost independent of the time. At 540° C. the hard-drawn tube was found to flow rapidly and to show considerable elastic after-effect, the immediate elastic recovery on the removal of a stress being followed by a slow backward flow lasting for several minutes. A similar effect, but much less in degree, was found to be present in the annealed tube. The apparatus employed was described in a previous paper [see Abs. 1026 (1914)].

J. W. T. W.

**632.** *Researches on Fragility. "Bursting."* **C. de Fréminville.** (Rev. de Met. 11. pp. 971–1056, Sept., 1914.)—A detailed study of the phenomenon of "bursting" has been made with a view to throwing some light on fragility. Bursting is described as a sudden and brutal mode of fracture which, when fully developed, results in the flying to pieces of the body in which it is produced. Fractures produced by it assume the same appearances in both brittle and ductile materials. Generally, bursting occurs in a region having no direct contact with the exterior, and is brought about by the action of internal stresses. Examination of a specimen which has "burst" reveals the existence of a number of planes of division originating from a small peculiarly oriented surface (usually situated at some distance from the place of impact) which has been called the source of bursting. All fractures have their origin in an initial burst occurring in the interior of the mass, and development only takes place by a succession of bursts. The original burst is produced in a region where the main stress is positive but not necessarily where the stress attains its max. value. All things being equal in other respects, the stress normal to the principal stress determines the danger of fracture. In a long paper which does not lend itself to short abstraction the author describes and illustrates the modes of fracture of glass and bitumen under impact and applies the results obtained to the study of steels.

F. C. A. H. L.

**633.** *Temperature-changes Due to Adiabatic Volume-changes in Steel.* **K. T. Compton** and **D. B. Webster.** (Phys. Rev. 5. pp. 159–166, Feb., 1915.)—Gives a full account of previous work on the verification of Kelvin's formula for finding the change of temperature in a substance due to adiabatic compression or extension. In the best previous experimental determinations on wires, thermo-couples were employed for the measurement of the temperature change, but as this change is generally exceedingly small, a method depending on the measurement of the change of resistance of the wire itself is several hundred times as sensitive. Further, such a method is free from any errors due to the Peltier-effect which is a disturbing factor in thermocouple determinations. It is shown theoretically that, for a highly damped galvanometer such as that used in the authors' experiments, after about

30 secs. the deflection of the galvanometer at any instant accurately records the temperature of the wire at that instant. Hence by observing the deflections every 5 secs. and extrapolating the curve to zero, the actual temperature at the instant of application of the load may be deduced. The authors have used this method in experiments on steel piano-wire subjected to sudden tensions ranging from 5 to 15 kg. (care being taken to ensure that there was no elastic lag at these loads). The results obtained agreed with the theoretical value to within 0·4 %, whereas the best previous determinations showed a discrepancy at least ten times as great as this. J. W. T. W.

634. *Theory and Use of the Molecular Gauge.* **S. Dushman.** (Phys. Rev. 5. pp. 212–229, March, 1915.)—A theoretical study of the "molecular" gauge for measuring very small gas pressures described by Langmuir [Abs. 725 (1914)]. This gauge consists of a glass bulb containing a horizontal disc rotatable by means of a rotating magnetic field produced outside of the bulb. A second disc is suspended above the rotatable disc by a quartz fibre and carries a mirror. It is found that the rate B at which momentum is transferred per unit area from a surface moving with velocity $u$ is $B = kup\sqrt{M/RT}$, where $p$ is the pressure of the gas and $k$ a constant varying with the nature of the gas and with that of the surface with which it is in contact. With the particular gauge employed, a deflection of 1 mm. at a distance of 50 cm. corresponds with $0·8 \times 10^{-6}$ bar when the disc rotates at 1000 revs. per min. If the speed be increased to 10,000 revs. per min., it should be possible to measure a pressure of about $10^{-4}$ bar. The mirror is fixed in an Al framework on the fibre and the apparatus is free from any part which cannot withstand a temperature of about 300°. Various correction factors are discussed and the results of measurements described. The vapour pressure of ice at −78° is found to be about 0·2 bar. The theoretical conclusion that the indications of the gauge at constant pressure should vary as the square root of the molecular weight of the gas is confirmed by replacing the air in the gauge by hydrogen. In a well-exhausted tungsten lamp the pressure is certainly well below $10^{-8}$ bar when the filament is lighted. The uses of other vacuum gauges are briefly discussed. T. H. P.

635. *Relative Dimensions of Molecules.* **A. O. Rankine.** (Phil. Mag. 29. pp. 552–555, April, 1915.)—It is well known that the knowledge of the viscosity of a gas makes it possible to calculate, upon the kinetic theory, the mean free path of the molecules, and hence their dimensions. According to Maxwell the relations are as follows: $\eta = 0·307\rho\lambda G$...(1), where $\eta$ is the viscosity, $\rho$ the density, $\lambda$ the mean free path, and G is the root-mean-square velocity of the gas molecules. The value of G is $\sqrt{3p/\rho}$, where $p$ is the pressure of the gas.

Further, the equation $\lambda = 1/(N\pi\sigma^2\sqrt{2})$...(2) gives the connection between the mean free path, the number N of the molecules per unit volume and $\sigma$ their radius. As was pointed out by Sutherland, however, the calculation of $\sigma$ by means of these two equations leads to inconsistencies, because the viscosity of a gas is not, in fact, proportional to the square root of the absolute temperature. Hence the value of $\sigma$ so estimated becomes smaller and smaller as the temperature corresponding to the viscosity datum increases.

The modification in the theory introduced by Sutherland was to take into account the forces of attraction which the gaseous molecules exert upon one another; and he showed that this involved that the mean free path was smaller than that estimated for forceless molecules in the ratio of $1 : (1 + C/T)$, where C is a constant and T is the absolute temperature. On this basis the viscosity of a gas was shown by Sutherland to be proportional to $T^{1/2} \div (1+C/T)$.

The present author has made experiments on the viscosities of various gases at different temperatures. The gases dealt with are argon, krypton, and xenon of the inert group, and chlorine, bromine, and iodine of the halogen group. The results are shown in the following table :—

| Gases. | Molecular Radii and Ratios. | Ratio of Molecular Masses (from molecular weights). | Ratio of Molecular Densities (from viscosities). | Values of C and their Ratios. |
|---|---|---|---|---|
| Chlorine : Argon... | $\frac{1 \cdot 6 \times 10^{-8}}{1 \cdot 28 \times 10^{-8}} = 1 \cdot 25$ | 1·78 | 0·93 | $\frac{325}{142} = 2 \cdot 3$ |
| Bromine : Krypton | $\frac{1 \cdot 71 \times 10^{-8}}{1 \cdot 38 \times 10^{-8}} = 1 \cdot 24$ | 1·93 | 1·01 | $\frac{460}{188} = 2 \cdot 4$ |
| Iodine : Xenon ... | $\frac{1 \cdot 88 \times 10^{-8}}{1 \cdot 53 \times 10^{-8}} = 1 \cdot 23$ | 1·95 | 1·02 | $\frac{590}{252} = 2 \cdot 3$ |

E. H. B.

**636.** *Field of a Single Centre in Einstein's Gravitation Theory.* **J. Droste.** (K. Akad. Amsterdam, Proc. 17. pp. 998–1011, Feb. 27, 1915.)—The equations which determine the field of gravitation in Einstein's and Grossmann's theory are not linear, hence the field corresponding to the resultant of two tensors is not the sum of the fields corresponding to the component tensors. The equations, however, present a certain homogeneity. These remarks show that the calculation of fields of gravitation is far more difficult in the new theory than in the old theory due to Newton.

The field of a single centre is then mathematically derived by a series of successive approximations. At a certain stage the calculation is in accord with the ordinary planetary motion as described by Kepler's laws. On passing to a further approximation, the theory indicates a motion of the perihelion, which amounts in the case of Mercury to 18 seconds of arc per century, the observed motion being 44 seconds. E. H. B.

**637.** *Motion of a Sphere in a Viscous Fluid.* **W. E. Williams.** (Phil. Mag. 29. pp. 526–552, April, 1915.)—The mathematical solution of the problem presented by the motion of a solid body moving with finite velocity through a viscous fluid has hitherto presented insuperable difficulties, and no solution has been obtained even for the apparently simple cases of a sphere or cylinder moving with uniform velocity along a straight line. The complicated nature of the equations of motion, together with the difficulties presented by the boundary conditions, which require that both the normal and tangential velocities should have specified values at the surface of the moving body, seem to place the direct solution of the problem far above the reach of any known method. The actual solutions of the problem which are given in the current text-books of hydrodynamics are obtained by ignoring some of the terms in the general equations of motion. These solutions may be divided into two classes, and looked upon as limiting cases of very high and very low velocities respectively. Nothing was really known as to the nature of the motion for values of the velocity which are neither very high nor very low, and the work here described was undertaken with the object of throwing some light on this problem, and in particular of determining the way in which the motion changes as the velocity is increased beyond the critical value.

The problem has been here approached both from the experimental and theoretical sides, and in order to simplify matters as far as possible the investigations have been confined to the case of a sphere moving with uniform velocity along a straight line. The actual motion of the fluid surrounding the moving sphere has been observed, and it has been found possible to photograph the motion, and to map out the stream-lines for velocities up to 720 times the critical value. At the same time certain mathematical solutions have been obtained which serve to throw some light on the changes which take place in the form of the motion as the velocity increases beyond the critical value.

The paper is illustrated by eight reproductions of the photographs of the motion and seven maps of the stream-lines round the moving body.
E. H. B.

638. *Orbits of Freely Falling Bodies.* **R. S. Woodward.** (Science, 41. pp. 492–495, April 2, 1915.)—A note as to the cause of the various results obtained by the author in 1913, by F. R. Moulton in 1914, and by W. H. Roever in 1915. It is pointed out that really somewhat different problems were solved in these cases and that the apparent discrepancy is not due to varying degrees of approximation in the calculation. E. H. B.

639. *Oscillations of Water in Circular-sectorial and Ring-sectorial Vessels.* **S. Sasaki.** (Tôhoku Univ., Sci. Reports, 3. pp. 257–270, Dec., 1914.)—The paper contains a detailed mathematical analysis of the problems in question, accompanied by 20 photographic illustrations of an experimental investigation made at the same time. Agreement between theory and experiment is found to be fairly good. H. H. Ho.

640. *Kelvin's Work on Gyrostatics.* **A. Gray.** (Inst. El. Eng., J. 53. pp. 277–307, Feb. 15, 1915.)—This is a very interesting summary derived mainly from Kelvin's published work, illustrated by diagrams and drawings of gyrostatic models. In a mathematical appendix the author gives a statement of the theory of a single gyrostat, using a simple vectorial method of forming the equations of motion, which he devised many years ago. Quite a number of problems are dealt with, including instructive applications to the motion of an electron in a magnetic field, and it should be noted as providing a remarkably simple method of approach to a very difficult subject, and one which can be followed by many who are unable to cope with the mathematical difficulties of the usual methods of attacking it. G. W. de T.

641. *Quaternions applied to Physics in Non-Euclidean Space.* **A. McAulay.** (Roy. Soc. Tasmania, Proc. pp. 1–19, 1914.)—This is the first paper of a series, and is devoted to the mathematical methods. Others are to follow dealing with particle and rigid dynamics, hydrodynamics, and various types of wave and vortex motions. E. H. B.

642. *Resistance to a Body moving in a Fluid.* **H. Levy.** (Roy. Soc. Edinburgh, Proc. 35. pp. 95–109, 1914–1915.)—A mathematical treatment by

which it is shown, contrary to Kármán's conclusions, that there is no completely stable arrangement of the vortices located behind the moving body.
E. H. B.

643. *Recent Evidence for the Existence of the Nucleus Atom.* **A. D. Cole.** (Science, 41. pp. 78–81, Jan. 15, 1915. Paper read before the Am. Assoc. for Advancement of Science, Dec., 1914.)—The author briefly summarises the more important contributions to the subject from 1912 to the earlier part of 1914, with a bibliography. It is not intended to be critical, but rather indicatory of the varied character of the lines of evidence developed within this period which give support to the hypothesis of a nucleus atom in some form.
G. W. de T.

644. *Atomic Model with a Magnetic Core.* **H. S. Allen.** (Phil. Mag. 29. pp. 714–724, May, 1915.)—The atomic model here suggested consists of a ring or rings of electrons surrounding a central core, having a radius considerably greater than the nucleus of the Rutherford atom, and in consequence capable of producing appreciable magnetic forces in its vicinity. The total charge of the core must be equal to N$e$, where N is the atomic number. The magnetic moment of the core arises from the orbital motion of the discrete electrified particles ($\alpha$-particles, $\beta$-particles, hydrogen nuclei or positive electrons) of which it is composed. The diamagnetic properties of the atom arise mainly from the external electrons revolving in orbits whose radius is of the order of $10^{-8}$ cm. The magneton is regarded not as an independent entity, but as a unit convenient for measuring magnetic moments introduced in consequence of the principle of the constancy of angular momentum. A consideration of the laws of spectral series suggests that the quantity $\mu$, the "phase" of the series, is connected with the angular momentum of the particular part of the core specially associated with the external electron concerned in radiation. A further study of the values of this quantity may lead to a more complete knowledge of the structure of the core. [See Abs. 1296 (1913).] A. W.

645. *Deep Waves, Progressive or Stationary, to the Third Order of Approximation.* **Rayleigh.** (Roy. Soc., Proc. 91. pp. 345–353, May 3, 1915.)—Mathematical.

646. *On Ripples.* **J. R. Wilton.** (Phil. Mag. 29. pp. 688–700, May, 1915.)—Mathematical.

647. I. *Equations of Motion of a Viscous Fluid.* II. *Two-dimensional Steady Motion of a Viscous Fluid.* **G. B. Jeffery.** (Phil. Mag. 29. pp. 445–455 and 455–465, April, 1915.)—Mathematical.

648. *Hydrodynamic Investigations on the Flow from Orifices.* **P. Allbrandi.** (N. Cimento, 8. pp. 415–439, Dec., 1914.)—A mathematical treatment.

649. *Relation between Departures from the Normal in the Strength of the Trade-winds of the Atlantic and those in the Water-level of the Northern European Seas.* **P. H. Gallé.** (K. Akad. Amsterdam, Proc. 17, pp. 1147–1158, April 28, 1915.)—Mean values from Norwegian, Dutch, German, and Finnish tide-gauges disclose an annual periodicity in the water-level of the North Sea and Baltic showing a minimum in Spring and a maximum in Autumn, with an amplitude of about 18 cm. The author considers it probable that these

fluctuations are caused by fluctuations in the strength of the North Atlantic current, which itself is a branch of the Gulf Stream. There is evidence that fluctuations in the strength of the Gulf Stream are closely associated with changes in the strength of the trade winds, and as observations of the trade winds are more numerous than current observations, an attempt is made to ascertain the correlation between the North Sea water-level and the trade-wind strength. Curves showing the annual variations of these two elements lend support to the theory that monthly fluctuations in the strength of the north-east trade winds are responsible for the monthly fluctuations in the water-level of the North Sea and Baltic, there being a time-lag of about 2¼ months in the action. In addition to this effect by the distant trade winds it is found that the local winds in the neighbourhood of the entrance to the Baltic from the North Sea also produce some effect on the water-level.

J. S. Di.

**650.** *The Robinson Anemometer.* **K. Schreber.** (Meteorolog. Zeitschr. 31. pp. 373–380, Aug., 1914.)—The results of experiments to determine the constants of a small cup anemometer (cups, 38 mm. in diam.—arms, 45 mm. long) are described. The anemometer was mounted in the centre of a box 35 × 35 × 50 cm. in dimensions, of which one end was open, while the opposite end could be opened or closed at will. The box was placed in the middle of the wind-channel of the Aerodynamical Institute at Aachen, and arrangements were made for recording automatically the time at which each revolution, or, if desired, each ¼-revolution of the cups was completed. In order to determine the constants of the anemometer, the following general relation between the angular velocity ($\omega$) of the cups and the velocity ($v$) of the air passing them was taken, it being assumed that the quantities $a$, $b$, $c$, $d$, $e$, and $f$ are constants of the instrument, independent of $v$ and $\omega$—

$$d\omega/dt = a + b\omega + cv + d\omega^2 + ev\omega + fv^2.$$

In order to determine the constants, two sets of experiments were carried out. In the first set the cups were made rapidly to rotate by opening the movable lid of the box and passing an air-current through the wind-channel; then the lid was suddenly closed, thus making $v$ zero, and the motion of the cups was recorded from that instant until the cups came to rest. The general equation reduces to—

$$d\omega/dt = a + b\omega + d\omega^2.$$

The constants $a$, $b$, and $d$ were determined from the results of the experiments. In the second set of experiments, the cups being initially at rest and the lid closed, a *constant* current was passed along the channel. The lid was then opened, and the motion of the cups began to be recorded from that instant. The general equation—

$$d\omega/dt = (a + cv + fv^2) + (b + ev)\,\omega + d\omega^2$$

could be written—

$$d\omega/dt = a' + b'\omega + d\omega^2$$

(where $a'$, $b'$ are constants depending on the constant velocity), an equation similar to the preceding. In this way all the constants of the general equation could be deduced, and the final result is—

$$(t + 4\cdot9)\,d\omega/dt = -1\cdot76 - 0\cdot667\,\omega + 0\cdot50v - 0\cdot098\omega^2 + 0\cdot140v\omega + 0\cdot84v^2.$$

The interesting case for meteorologists is that of the steady state when $d\omega/dt$ is zero, and the anemometer is rotating uniformly with angular velocity $\omega$ in a steady wind of velocity $v$. The relation between $\omega$ and $v$ is then found by equating the right-hand side of the equation to zero. For values of $v$ greater than 8 metres/sec. the solution reduces approximately to $v=0\cdot90+\omega/3\cdot74$, which gives a linear relation between the wind velocity and the rotation of the cups. [See Abs. 935 (1911).] R. C.

651. *Solar Radiation Measures in Egypt.* **Eckersley.** (Helwân Observatory Bull. No. 14. Nature, 95. p. 157, April 8, 1915. Abstract.)—Pyrheliometric measures of the solar radiation were made at the Helwân Observatory with the object of detecting variations of the solar constant. The value obtained is 1·782, considerably lower than the Mount Wilson value obtained by Abbot, 1·932. C. P. B.

652. *Influence of the Earth's Rotation upon the Motion of a Particle on its Surface.* **M. Radaković.** (Meteorolog. Zeitschr. 31. pp. 384–392, Aug., 1914.)—If a body of mass $m$ is moving under gravity on the earth's surface with velocity $v$, then the path of the body will not in general be a great circle because the rotation of the earth (angular velocity $=\omega$) will bring portions of the surface beneath the body as it moves, which were not initially directly in the path of the body. The result is that the body describes a curved path on the earth's surface, and the amount of the deflection from the direction of the initial great circle can be accounted for dynamically by assuming that the earth is at rest, and that a horizontal force, commonly known among continental writers as "the deflecting force of the earth's rotation," is acting at right angles to the path of the particle, directed to the right of the path in the northern hemisphere, and to the left in the southern hemisphere. Using elementary methods, it is shown that the amount of this force is $2m\omega v \sin\phi$, where $\phi$ is the latitude of the particle.

The remainder of the paper is devoted to an analytical discussion of various propositions on the motion of a particle on the earth's surface, by the methods of moving axes. R. C.

653. *Ice Observation, Meteorology, and Oceanography in the North Atlantic Ocean. Report on the Work carried out by the s.s. "Scotia,"* 1913. (Report to Board of Trade [141 pp.], 1914.)—Following the loss of the s.s. *Titanic* in April, 1912, it was arranged that the research ship *Scotia* should proceed to the North Atlantic ice zone to report on its movements and to make hydrographical, meteorological, and biological observations on the North Atlantic Steamship routes. The *Scotia* accordingly started in March 1913 from Scotland, and made her way across the Atlantic, cruised several times around and across the neighbourhood of the Grand Banks northwards to Davis Strait and Cape Farewell, and returned thence to Scotland in August. The results of the numerous observations are set out in tabular form and by means of diagrams, the latter occupying a separate volume. The scientific staff consisted of D. J. Matthews, hydrographer; G. I. Taylor, meteorologist; and also of a biologist, and the main part of the text consists of their three reports.

Matthews obtained full observations dealing with the bathymetry, salinity temperature, and ocean currents of the area, and noted the position of all the ice observed. The observations indicate the conditions at the boundary of the cold, relatively fresh, and slow-moving Labrador current, which flows south and south-east from Davis Strait into the Atlantic, and the warm, saline, and more rapidly-flowing Gulf Stream which flows across the path of the Labrador current from west to east and compels the latter to dive below.

Taylor's report is noteworthy for the fact that on 14 separate occasions he was able to raise a kite carrying self-recording meteorological instruments from the deck of the *Scotia*, and to deduce from the records obtained important results with regard to the rate of propagation of temperature-changes from the surface to the upper air, showing that the distribution of temperature in height is due to the action of eddies and resembles the process of heat conductivity in its mode of operation. New results regarding fog at sea are also obtained. In four of the kite ascents there was no fog, and the temperature uniformly fell with height (positive temperature gradient). The other ten cases were associated with negative temperature gradients, and in nine of them fog was noted to be present. Fog-production appears to depend upon the mixing by eddy-conductivity of layers of different temperatures and humidities, rather than upon the cooling below the dew point of a homogeneous mass of air. With regard to the suggested detection of the presence of icebergs from their effect upon the temperature of the sea, the conclusion is reached that in the regions visited by the *Scotia*, the results obtained do not bear out the suggestion. R. C.

**654.** *Macroseismic Movements of* **1911–1914** *in North Portugal.* **P. de Sousa.** (Comptes Rendus, 160. pp. 348–350, March 15, 1915.)—The Minho province in N. Portugal has experienced extensive macroseismic movements during the years 1911–1914 and the present paper contains the results of an investigation of the same. They seem to be of epirogenic origin and have a max. intensity along the seismic line Paços de Ferreira-Vila Nova de Familicão-Barcellos-Caminha, with a maximum of extension along the line Vila de Conde-Malta-Gondomar. H. H. Ho.

**655.** *The Conditions of Natural Gas in the Earth's Strata.* **G. A. Burrell.** (J. Indust. and Eng. Chem. 7. pp. 322–324, April, 1915. Paper read before the Am. Chem. Soc., April, 1914.)—This paper contains observations and experiments regarding the liquid or gaseous occurrence of natural gas in the earth's strata. Up to date, definite conclusions have been difficult to draw owing to insufficient data respecting the exact composition of natural gases. Knowing (1) the composition of a natural gas, (2) rock pressures and temperatures that prevail in natural gas strata, (3) the temperature and pressures necessary for the liquefaction of the gaseous paraffin hydrocarbons, evidence can be obtained regarding the liquid or gaseous occurrence of natural gas. Tables are given showing the vapour pressures and critical constants of the various paraffin hydrocarbons and the results of a eudiometric analysis of natural gas. From a consideration of available data the author concludes that the essential constituents of Pittsburg natural gas never occur in the strata in the liquid form, because rock pressures are not high enough, rock temperatures are not low enough, and the quantities of the more easily condensable constituents in the gas mixture are not great enough for this condition. The state of natural gas in the earth is of importance, for, if present therein as a liquid, it would be possible for a single subterranean reservoir to furnish a much larger supply of gas than if present in the gaseous condition. Somewhat different from ordinary natural gas, which is contained in rock strata under heavy pressure, are those gases which issue from the casing heads of oil wells under slight pressure, or are withdrawn from the casing heads at pressures less than atmospheric. These gases frequently contain enough vapours of liquid paraffin hydrocarbons to warrant the installation of a gasoline condensation plant. The quantities of more easily liquefied gases are much higher than in the so-called dry gases, but the pressures in the rock strata from which they issue or are drawn are invariably much lower, so that the chances of them occurring in the liquid condition are small. H. H. Ho.

656. *Anomalies in the Distribution-of-Temperature Curves for Western Africa.* **H. Hubert.** (Comptes Rendus, 160. pp. 868–870, March 22, 1915.)—If the temperature distribution on the earth's surface only depended on the amount of heat received from the sun, the isothermal lines would be parallel to the equator, and would give rise to a series of zones having uniformly decreasing temperatures from a central zone. These would be displaced alternately from one tropic to the other with the apparent motion of the sun. This theoretical movement, however, is subject to serious modifications in West Africa. The present paper does not deal with local variations due to coast proximity, trade winds, etc., but with more general modifications due to the massive shape of West Africa, its geographical position, wind and rainfall conditions, etc. Each month in the year is reviewed with respect to the minimum, maximum, and average temperature conditions. H. H. Ho.

657. *Vortex Experiments on Motion of Sun-spots.* **G. E. Hale.** (Science, 41. p. 569, April 16, 1915. Paper read before the Nat. Acad. of Sciences.)—A closely wound helix of brass wire, with circular discs threaded on it, is hung vertically in water and spun at high velocity. The columnar vortex thus formed gradually changes into a semicircular vortex ring by the rise of the lower end of the helix until it meets the surface. The experiment suggests that the second sun-spot in a typically bipolar group might be formed by the turning-up of the columnar vortex assumed to constitute a single spot. Preliminary rotation of the whole mass of liquid retards or prevents the turning-up process if in the same direction as that of the helix, and hastens it if in the opposite direction.

Circular or semicircular vortices have a proper motion at right angles to their planes, in the direction of motion of the inner edge of the whirling ring. Therefore as high- and low-latitude bipolar spots rotate in opposite directions, they should move towards the pole and equator respectively, and Carrington's observations show that this is the case. Observations are being continued on the stream-lines of ionised smoke particles, above single and double magnetic vortices representing sun-spots. C. P. B.

658. *Solar Prominence of October* 19–21, 1914. **O. J. Lee.** (Astrophys. J. 41. pp. 168–169, March, 1915.)—An illustrated description is given of the interesting eruptive prominence photographed with the Rumford spectroheliograph at the Yerkes Observatory on Oct. 19, 20, 21, 1914. On one plate its height was 430″, corresponding to 308,000 km. Measurements on recognisable features give the velocities of eruption at various epochs. C. P. B.

659. *Flash Spectrum without Eclipse.* **W. S. Adams** and **C. G. Burwell.** (Astrophys. J. 41. pp. 116–146, March, 1915.)—The paper is in continuation of a previous one giving the preliminary results of photographs of the spectrum of the sun's limb obtained during ordinary sunlight by projecting a large

image on the slit of a powerful spectrograph [Abs. 24 (1910)]. The tables show the wave-lengths of the bright chromospheric lines found, with their origins and corresponding intensities in the Fraunhofer spectrum. More lines are measured than have been recorded on the best eclipse photographs, and the accuracy of the wave-lengths is much greater on account of the use of a slit. Moreover, because the slit was held rigorously tangential to the sun's limb throughout the exposure, it is thought that the spectra represent a lower level in the chromosphere than the eclipse spectra, which depend on the motion of the edge of the moon. The wave-lengths in general agree so closely with those of the dark Fraunhofer lines that it is concluded there is little evidence for suspecting the presence of anomalous refraction to any effective extent.

C. P. B.

660. *Photographic Photometry with Wire Diffraction Gratings.* **S. Chapman.** (Observatory, No. 485. pp. 133–136, March, 1915.)—By attaching a wire grating over the object-glass cell of a photographic telescope there is formed at the focus a central image and a series of lateral diffraction spectra of gradually diminishing brightness. Taking advantage of the general principle that the relative proportions of the whole light going to the various images of a star are independent of the intensity of the original beam, it is possible to base a system of accurate stellar photometry on the measurements of the densities or sizes of the central and lateral images. The proportion of these light-accumulations depends on the ratio of the width or diameter of the wires to the distance between adjacent wires. Hence, if on a plate it is found that the central image of one star is identical in size and blackness with the first diffracted image of another, it is true that the second star is brighter than the first in the known ratio determining the relative brightness of the central and first diffracted image of any star. An important advantage of the method is that the auxiliary images are formed at the same time and under the same circumstances as the central image, the magnitude intervals thus being independent of the constancy of atmospheric transparency during the exposure of the plate. The difficulty that the lateral images are really small elongated spectra may be overcome by suitable design of the grating. In an actual grating used with the 26-in. Thompson refractor at Greenwich the aperture of the grating is 30 in.; diam. of wires, 0·693 mm.; separation of wires, 5 mm. This system gives a magnitude of 4·04 calc., 4·18 observed. A star-field photographed with the apparatus is given with the paper to illustrate the method.

C. P. B.

661. *Determination of Astronomical Refraction.* **G. Bigourdan.** (Comptes Rendus, 160. pp. 190–194, Feb. 8, 1915.)—Determinations of astronomical refraction have hitherto been generally made from observations with a meridian circle on stars culminating at different altitudes, but it is now important to know if the "constant of refraction" is really a constant quantity, if it is the same in different azimuths, in different seasons, and in different parts of the globe, and the author proposes to utilise the special qualities of the angular comparator recently devised by him for the investigation [see Abs. 517 (1915)]. Pairs of stars are chosen which may be observed simultaneously in the two telescopes of the comparator, and the instrument being driven by clockwork to follow the diurnal motion, the alterations of their distance due to varying degrees of refraction may be very accurately determined with eyepiece micrometers.

C. P. B.

662. *Measures of Saturn's System.* **P. Lowell.** (Lowell Observatory, Bull. No. 66. 2. No. 16. Nature, 95. p. 156, April 8, 1915. Abstract.)—From Dec. 1913 to March 1914 a series of measures of the ball, rings, and satellites of Saturn were made with the 24-in. refractor of the Lowell Observatory, Arizona, and tables are given of the results reduced to mean distance of the planet. C. P. B.

663. *Red Region of Wolf-Rayet Star Spectra.* **J. Bosler.** (Comptes Rendus, 160. pp. 124–128, Jan. 25, 1915.)—Photographic observations have been secured of several Wolf-Rayet star spectra in the red region, using Lumière violet plates sensitised with dicyanin, in a prismatic camera of 0·25 m. aperture and 0·75 m. focus. Details are given of the stars' positions, magnitudes, and lines measured in each spectrum. The lines shown are due to hydrogen, helium, and some unknown substance. C. P. B.

664. *Structure of $H_\gamma$ in Stellar Spectra.* **A. Knatek.** (Astron. Nachr. 200, No. 4788. Nature, 95. p. 99, March 25, 1915. Abstract.)—A summary is given of the measurements of intensity and width of the $H^\gamma$ line in the spectra of stars of different spectral types. The intensity and width appear to vary together, and have minimum values in the G-K stars, attaining max. values in the stars of class A. C. P. B.

665. *Table of Stellar Parallaxes and Sun's Magnitude.* **R. Innes.** (Union Observatory of S. Africa, Circ. No. 5. pp. 43–44, 1913.)—Assuming the sun's stellar magnitude to be —26·57, this value being adopted because it is 5 times the logarithm of the radius in seconds of arc, the table shows what the sun's magnitude would be at varying distances estimated in light-years, with the corresponding equivalent stellar parallaxes. C. P. B.

666. *Star Positions from Wolf-Palisa Charts.* **R. Innes.** (Union Observatory of S. Africa, Circ. No. 8. pp. 59–64, 1913.)—It is found that in the regions for which the Wolf-Palisa star charts are available, they replace Durchmusterung or even Zone Catalogues of stars. When used at the telescope for identifying stars, the places can be read off by inspection with an accuracy always sufficient for re-finding with the equatorial, and it is found much easier to identify stars by means of maps than with Durchmusterung catalogues. A test was made by measuring one of the charts with a mm. scale, and comparing the results with the catalogue places, showing that by this simple means even more accurate places could be obtained from the maps than from the catalogues. A long discussion is given of the possible accuracy attainable in measuring star places on enlargements of star maps. C. P. B.

667. *Photographic Star Charts in Place of Durchmusterungs.* (Union Observatory of S. Africa, Circ. No. 16. pp. 112–113, 1914.)—In continuation of a former note [see preceding Abs.], a specimen of the Wolf-Palisa chart furnished with galactic rulings is reproduced, indicating the method adopted for recording data about each star. C. P. B.

668. *Discovery of Variable Stars with the Blink-microscope.* **R. Innes.** (Union Observatory of S. Africa, Circ. No. 20. pp. 149–154, 1914.)—By applying the Pulfrich Blink-microscope to the comparison of two photographic plates of the same star region, taken at different epochs, it is found possible to detect

variable stars, minor planets, etc., very readily, and with less eyestrain than by the ordinary method of comparison with a simple magnifier. A list of 110 variable stars found by the method is appended. C. P. B.

**669.** *Determination of Star Places with Wide-angle Camera.* **F. Schlesinger.** (Observatory, No. 485. pp. 129–133, March, 1915.)—This is a more detailed description of the use of a doublet lens for photographing star fields than that given in a previous paper [see Abs. 419 (1915)]. The optical part consists of a symmetrical doublet by Brashear, aperture 8 in., focal length 64 in., giving measurable images up to 4° from the axis. Full illumination of central and marginal pencils is secured by the insertion of a 8-in. diaphragm between the lens combinations. C. P. B.

**670.** *Spectrum of η Carinæ.* **R. F. Sanford.** (Lick Observatory, Bull. 8. [No. 267] p. 134, 1915.)—Two further spectrograms have been obtained with the one-prism spectrograph at the Lick Observatory. Details are given of the radial velocities determined by measures of different lines, the chief result being that the velocity from discussion of the hydrogen lines appears to be positive, while that from the other lines in the spectrum is negative, indicating motions in opposite directions. The hydrogen line $H_\beta$ appears as a broad line, with no evidence of doubling. Observations of 1913, 1914 show no evidence of variation in radial velocity. C. P. B.

**671.** *Stars with Variable Radial Velocity.* **R. E. Wilson.** (Lick Observatory, Bull. 8. [No. 267] pp. 124–127, 1915.)—Particulars are given of 14 stars whose radial velocity has been found to vary, from spectrograms taken by the D. O. Mills expedition to the southern hemisphere. C. P. B.

**672.** *Orbit of Spectroscopic Binary ε Volantes.* **R. F. Sanford.** (Lick Observatory, Bull. 8. [No. 267] pp. 127–130, 1915.)—This star, magnitude 4·5, was found to be a binary from plates taken in 1907–8. Elements of the orbit were determined from measures of 8 lines in the spectrum. The period is about 14 days. C. P. B.

**673.** *Orbit of Spectroscopic Binary υ Centauri.* **R. E. Wilson.** (Lick Observatory, Bull. 8. [No. 267] pp. 130–131, 1915.)—The spectrum of this star is classed as $B_3$, and the orbital elements have been found by measurement of 8 lines due to hydrogen, helium, magnesium, and carbon. The period is given as 2·62 days. C. P. B.

**674.** *Orbit of Spectroscopic Binary υ Sagittarii.* **R. F. Sanford.** (Lick Observatory, Bull. 8. [No. 267] pp. 132–133, 1915.—The spectrum is of type B8*p*, and is composite. About 25 lines were measured in determining the orbit. Period is about 137·95 days. C. P. B.

**675.** *Angular Diameters of Stars by Elliptically Polarised Light.* **S. Pokrowsky.** (Astrophys. J. 41. pp. 147–158, March, 1915.)—A description is given of a simple stellar interferometer, in conjunction with a telescope provided with a Wollaston double-image prism, astrophotometer and ocular. Formulæ are developed for the evaluation of the angular diameters of stars observed, but no examples are shown of any results. C. P. B.

**676.** *Determination of Period of ρ Leonis.* **F. Schlesinger.** (Astrophys. J. 41. pp. 162–167, March, 1915.)—It frequently happens that an observer has accumulated a large number of plates of the spectrum of a star suspected of being a spectroscopic binary without being able to determine the period, possibly owing to the amplitude being very small. A method is suggested which consists in first constructing a frequency curve for the velocities, and then comparing this with the usual curve of errors. If they agree it may generally be assumed that the star is not a true spectroscopic binary, there being at present no star known with a curve similar to the error-curve. If the curves are dissimilar, the investigation may be carried further by assumptions as to the eccentricity; and the method is illustrated by an examination of the orbit of ρ Leonis, resulting in a period of 12·28 days. C. P. B.

**677.** *Rotation of Nebulæ.* **V. M. Slipher.** (Nature, 95. p. 185, April 15, 1915.)—Photographs of the Virgo nebula, N.G.C. 4594, taken in April 1913, with an exposure of 80 hours, showed the spectrum lines inclined and with a large displacement in wave-length. The slit being placed east and west, the inclination of the lines is such that it indicates the rotation to be in the sense that brings the west side of the nebula towards the earth. The displacement indicates a recession of 1100 km. per sec.

Another photograph of the Crab nebula, N.G.C. 1952, taken in Feb., 1915, with 18 hours' exposure shows the well-known bright-line spectrum of nebulæ, but the lines have very unusual characteristics. They seem to be split into doubles, especially at λ5007 and λ4861, the distance between the components changing with different portions of the nebula on the slit. The appearance is strongly suggestive of the photographs shown by Zeeman of spectrum lines in a non-uniform magnetic field. The max. separation observed is 40 Å. C. P. B.

**678.** *Nature of the Zodiacal Light.* **F. Schmid.** (Archives des Sciences, 39. pp. 149–166, Feb., and pp. 237–246, March, 1915.)—The suggestion is made that the zodiacal light may be due to sunlight reflected from the lenticular segment of the earth's atmosphere produced by the equatorial protuberance due to rotation. The difficulty that the phenomenon follows very closely the axis of the ecliptic, and not the equator, is explained by suggesting that the atmospheric protuberance is displaced by the gravitational action of the sun and planetary systems, all of which are nearly in the ecliptic plane. The idea is elaborated by several excellent diagrams showing the coincidences with the observed phenomena. C. P. B.

## LIGHT.

**679.** *Canadian 72-inch Reflector.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J., Nov.–Dec., 1914. Nature, 95. p. 17, March 4, 1915. Abstract.)—Good progress is reported with the large reflector being figured by Brashear for the Canadian Government. The glass disc is 73⅝ in. in diam., 13¼ in. thick and weighs 4962 lbs. The instrument is to be used in the Cassegrain form, necessitating the drilling of a central hole 10 in. diam., and this delicate operation has now been satisfactorily completed. C. P. B.

**680.** *Theory of Dispersion.* **D. N. Mallik.** (Phil. Mag. 29. pp. 465–483, April, 1915.)—A discussion of dispersion and allied phenomena on the electron theory. The various equations appropriate to an elastic medium are finally found to have their analogies in the electric theory. But it does not seem to be possible to pronounce in favour of any one scheme of identification of the various quantities in preference to the others. Thus, in the relations $V^2 = 1/k\mu = n/\rho$, the identification of the rigidity $n$ or of the density $\rho$, with either of the electromagnetic quantities $k$ and $\mu$ is left undecided. E. H. B.

**681.** *Diffraction Phenomena and Motion of the Earth.* **A. Leduc.** (Comptes Rendus, 160. pp. 316–318, March 8, 1915.)—Attention is drawn to a required correction in the formulæ published by Mascart (Annales de l'École Normale, 1872) for calculating the modification of the simple sine law for the diffraction spectrum of a grating when the grating suffers displacement. The absolute and apparent displacements should be distinguished in the computation. C. P. B.

**682.** *Fresnel's Coefficient for Light of Different Colours.* I. **P. Zeeman.** (K. Akad. Amsterdam, Proc. 17. pp. 445–451, Sept. 26, 1914.)—One of the empirical foundations of the electrodynamics of moving bodies in the domain of optics is Fizeau's celebrated experiment on the carrying along of the light-waves by the motion of water. Let $w$ be the velocity of water relative to an observer, then for him the velocity of light propagated in the water would be $C_a = c/\mu \pm w$ if the dynamical laws for the addition of velocities were perfectly general. In this equation $\mu$ is the index of refraction of water, $c$ the velocity of light *in vacuo*. Fizeau showed that not the entire velocity, $w$, but only a fraction of it comes into action. This particular fraction appeared to be approximately $1 - 1/\mu^2$, Fresnel's coefficient. Hence we must write in place of the above formula $C_a = c/\mu \pm \epsilon w$...(1), where $\epsilon = 1 - 1/\mu^2$...(2). For water $\epsilon$ is 7/16.

The important rôle which equations (1) and (2) have had in the theory of aberration, in the development of Lorentz's electronic theory needs no emphasis, but it may be noted that equation (1) is now regarded as a simple confirmation of Einstein's theorem concerning the addition of velocities.

The smallness of the second term of (1) should be noted. Thus, if for water, $w$ is of the order 5 m. per sec., it is necessary to detect a difference of velocity of 5 m. in $\frac{3 \times 10^8}{4/3}$ m., *i.e.* of one part in 50 millions.

In 1895 H. A. Lorentz gave a new formula, viz. $\epsilon=1-1/\mu^2-1/\mu.\lambda d\mu/d\lambda$...(3). For the wave-length of the sodium lines this becomes 0·451. Hence the value by Lorentz's formula deviates from that by the simple one in (2).

The general result of the present experimental research is that for water there exists a *dispersion* of Fresnel's coefficient and that formula (3)—and, accordingly, the third term of Lorentz—is essentially correct.

The full details of the arrangements and the experiments are to be given in the second part. E. H. B.

683. *Signal Propagation in Dispersive Media.* **W. Colby.** (Phys. Rev. 5. pp. 253–265, March, 1915.)—By integrating the Fourier integral in the complex plane, a study has been made of the progress of a light "signal" incident obliquely at the plane boundary of a dispersive medium.

The forced vibration of the refracted wave has been deduced with the familiar changes in amplitude, phase, and state of polarisation.

An expression has been found for the refracted "forerunners" reducible to the form in Sommerfeld's paper for normal incidence and small values of time. The forerunners are found in general not to differ from the type described by Sommerfeld except in magnitude of amplitude and period, both quantities decreasing with increasing obliquity. The direction of the refracted ray is found to be a function of the time, varying from the incident direction at the first instant continuously toward the normal. The reflected ray has also a train of forerunners of extremely small amplitude and period. [See Abs. 1413 (1914).] E. H. B.

684. *Variation of the Magnetic Birefraction of Colloidal Iron with Temperature.* **L. Tieri.** (Accad. Lincei, Atti, 24. pp. 330–335, March 12, 1915.)—Majorana (1902) discovered the existence of three types of dialysed colloidal iron solution, with (1) positive birefraction, (2) negative birefraction, and (3) positive birefraction for weak fields, this diminishing and changing in sign as the strength of field is increased. Schmauss [Abs. 1951 (1904)] found that, with a sample of Bravais iron exhibiting at the ordinary temperature negative birefraction, the latter diminished to zero as the temperature was raised to 52° to 54°, and became positive at still higher temperatures; the original properties were restored on cooling.

The author's examination of various types of active dialysed iron showed that each is capable of exhibiting negative, zero or positive birefraction at different temperatures. Thus, a solution with negative birefraction at the ordinary temperature undergoes inversion when heated, and one which is positively birefringent at the ordinary temperature suffers inversion when cooled. It is found, further, that every colloidal iron solution showing magnetic birefraction acquires, for a definite strength of field, the max. negative birefraction at the temperature of solidification of the solution. The positive liquids exhibit increased activity if they are diluted with alcohol in place of water; such dilution renders possible a greater lowering of the temperature with consequent increase in the negative birefraction.

Schmauss's hypothesis, according to which colloidal iron solutions containing large granules are positively, and those containing small ones, negatively birefringent, would afford an explanation of the effects of (1) rise of temperature, which would increase the size of the particles, and (2) the presence of alcohol, assuming that the latter causes diminution of the magnitude of all the granules. Ultramicroscopic examination does not, however, reveal any appreciable difference in size between the particles of the positively and the negatively birefractive solutions, but it must be remembered that these particles are scarcely visible and are present in large numbers. T. H. P.

685. *Electron Theory of Optical Properties of Metals.* I. **G. H. Livens.** (Phil. Mag. 29. pp. 655–672, May, 1915.)—A detailed analysis of the motion of the electrons in the metal along lines suggested by Thomson and Lorentz leads to the formulation of a complete theory for the action of the most rapidly alternating fields in the metal. Moreover, this theory is perfectly consistent with the special deductions given by Lorentz in the particular case of steady fields, and in this respect shows a distinct advantage over the form of theory proposed by H. A. Wilson. E. H. B.

686. *Absorption by a Resonant Gas.* **L. Bloch.** (Comptes Rendus, 160. pp. 341–343, March 15, 1915.)—A mathematical discussion, on the electromagnetic theory, of the dissipation of the energy of light by a gas, the natural period of whose molecules is nearly or exactly that of the incident light.

E. H. B.

687. *Series Spectrum of Hydrogen and Structure of the Atom.* **H. S. Allen.** (Phil. Mag. 29. pp. 140–143, Jan., 1915.)—Measurements of the wave-lengths of the first 6 lines of the hydrogen series show that Balmer's formula is not exactly applicable [see Abs. 1831 (1914)]. The author has recently found (Ibid. p. 40, 1915) that a formula of the type given by Ritz can be deduced by the method of Bohr's theory if the magnetic field of the atom be taken into account. Since Bohr's theory of spectral series has been successfully applied to the hydrogen spectrum, the author considers it of interest to ascertain if the inclusion of the effect of a magnetic field would lead to results consistent with the observations. The results obtained show that, although the values obtained for N by the formula of Curtis are slightly more consistent among themselves than those arrived at on the hypothesis of magnetic action, the divergence in the latter case is not too large to render this hypothesis untenable. The values given for 5 magnetons are slightly better than those for 6 magnetons. The view that the central core of the atom contains 5 magnetons is supported by the fact that the magnetic moment produced by an electron moving in a circular orbit with angular momentum $h/2\pi$ is exactly 5 magnetons; the series constant N would then be 109579·26 and the convergence frequency of the series 27419·815. On the other hand, the hypothesis that the core contains 6 magnetons appears to receive support from the observed diamagnetic properties of hydrogen; the magnetic moment of the core in a state of this type would then be 3 times (corresponding to $m = 3$) the moment of a sphere rotating with the angular velocity specified in earlier papers, and this would give 109679·25 for the series constant and 27419·813 for the convergence frequency. Hence it appears possible to account for the series spectrum of hydrogen on the lines of Bohr's theory combined with the assumption that the core of the atom can produce a magnetic field equivalent to that set up by either 5 or 6 magnetons.

T. H. P.

688. *Remarks regarding the Series Spectrum of Hydrogen and the Constitution of the Atom.* **L. Vegard.** (Phil. Mag. 29. pp. 651–655, May, 1915.)—The author considers various conclusions following from the suggestions made by Allen [see preceding Abstract]. The 5 or 6 magnetons necessary to explain

the deviations from the Balmer formula in the way proposed by Allen must be due to a magnetic system near the centre, and are not to be identified with the 5 magnetons produced by the light-emitting electron in the normal state of the atom. In order to obtain a magnetic moment of 5 magnetons it is necessary to assume an angular momentum of $1800h/2\pi$, and the number of rotations in unit time would be $4 \cdot 6 \times 10^{21}$ and the kinetic energy $2 \cdot 8 \times 10^{6}$ ergs or about 19 times the energy of the outer electron in the normal state of the atom. It cannot be asserted that the existence of such rotations and of this enormous store of energy are impossible, but there seems no special reason to assume them unless it is supposed that the internal energy of the atom brought to light through the atomic disintegration is to be of a rotational nature, and that the rotations are preserved also for the lighter elements like hydrogen. Allen does not indicate how the passage of the electron from one stationary circle to the next can increase the magnetic moment from 0 to 5 magnetons. Certain modifications of Allen's assumptions render it possible to explain the deviation from the Balmer formula through the magnetic influence of the inner core, when a constant difference of momentum of $h/\pi$ is supposed to be maintained between the outer and inner systems. It seems scarcely possible to suppose that a system with so much energy as the magnetic core of 5 magnetons would be affected essentially by the passage of the outer electron from one stationary circle to the next, since the inner system should take up the whole of the energy involved in the production of the magnetic field of 5 magnetons. T. H. P.

689. *Absence of Line at λ6708 in Calcium Spectrum.* **H. G. Woodward.** (Astrophys. J. 41. pp. 169–171, March, 1915.)—Several experimenters have recorded a line at λ6708 in the spectrum of calcium, and a line at this position was found by Hale and Adams in the spectrum of sun-spots. It is well known that the strongest line of lithium is at this wave-length, and the probability is that the line appears in the calcium spectrum as an impurity. No line near this position was found in the spectrum of specially prepared calcium carbonate. C. P. B.

690. *Electric Furnace Spectra of Vanadium and Chromium.* **A. S. King.** (Astrophys. J. 41. pp. 86–115, March, 1915.)—Photographs of the electric furnace spectra of vanadium and chromium were obtained with the furnace operated at various determined temperatures, and the resulting spectrum lines are classified according to (*a*) the initial temperature at which a line appears, (*b*) the rate of increase of intensity as the temperature rises. [See Abs. 1817 (1913); 1415 (1914).] The tube resistance furnace was operated *in vacuo*, and the new 15-ft. vertical concave grating spectrograph employed, using the second order giving a dispersion of 1·85 Å. to 1 mm. Complete tables are given showing the intensities of the line at three stages of temperature, with illustrations demonstrating the chief features of the variations. It is especially noted that the banded spectra characteristic of the arc are absent from the furnace spectra of these two metals. C. P. B.

691. *Variations of Spectrum Lines in Series.* **T. Royds.** (Astrophys. J. 41. pp. 154–161, March, 1915.)—It has been generally assumed that spectrum lines belonging to the same series are similar in character and in behaviour under different experimental conditions, so that it is of interest to find that in the first subordinate *triplet* series of barium the character of the lines varies in the course of the series. Thus the first members from λ5819 to λ5424, are

all unsymmetrically widened towards the red, while the second members, from λ4498 to λ4264, are unsymmetrically widened towards the violet. There seems to be no doubt that all the lines do belong to the same series, as all the necessary criteria for the formula are satisfied.

It is also found that the first subordinate series lines of calcium are also divisible into two dissimilar portions, the variation being somewhat less marked than in the case of barium, while in the spectrum of strontium the lines appear to be quite normal.

Attention is drawn to the importance of studying the behaviour of these spectra under pressure, at the same time care being taken to note the effect of vapour density, which also has a definite effect on the shift of lines, especially on unsymmetrical lines. C. P. B.

692. *Laws of Series Spectra.* **J. W. Nicholson.** (Roy. Soc., Proc. 91. pp. 255–272, April 1, 1915.)—Several theories of the production of series spectra have been given in recent years, and it has become apparent that no further real progress can be made in the interpretation of spectra until the true form of the series relations is known more accurately. Various formulæ, such as those of Ritz and Hicks, fit the measured wave-lengths almost equally well, and all demonstrate at least the approximate truth of two fundamental results—namely: (i) that the diffuse and sharp series tend to the same limits, and (ii) that the difference between the limiting wave-numbers of the sharp and principal series is the wave-number of the first principal line. The first is now usually taken as proved, but no formula has yet made it evident that the second—the Rydberg-Schuster law—is more than a close approximation. One of the objects of the present paper is to show that it is an absolute law. Another fundamental question, on which different opinions are held, is that of Rydberg's constant. Hicks has concluded that this constant may be slightly different in the various series produced by helium. According to Bohr's theory of spectra [Abs. 1930 (1913)] it should be an absolute constant for all the ordinary helium series, but different from the hydrogen constant by a calculable amount. It is shown that the limits of series with many lines, for which a Hicks formula is already known, can be calculated with extreme accuracy by a new method. The interferometer measures of the leading lines of the helium series enable the best form of the series to be obtained, and this form is an extension of that of Rydberg, dependent on $(m + \mu)$ and not $m$. The best form is found to be $\nu_m = A - N/\rho_m^2$, where $\rho_m = m + \mu + \alpha/(m + \mu) + \beta/(m + \mu)^2 + \ldots$. The value of Rydberg's constant 109679·2 given by Curtis [Abs. 1831 (1914)] for hydrogen only is found to be the true value for the arc spectrum of helium, and is in fact a rigorous constant for arc spectra. Spark spectra are not treated. The calculations made show that the Rydberg-Schuster law of limits is exact for helium. It seems probable that $\mu$ is a simple fraction whose denominator is a multiple of 5, as Halm has suggested. It is exactly 0·7 for the sharp series of helium, which can be represented with great accuracy by the formula $\nu = 29223{\cdot}780 - 109679{\cdot}2/\rho_m^2$, where $\rho_m = m + 0{\cdot}7 + 0{\cdot}018546/(m + 0{\cdot}7) - 0{\cdot}077181(m + 0{\cdot}7)^2 + 0{\cdot}02276/(m + 0{\cdot}7)^3$. A. W.

693. *Structure of some Spectrum Lines of Bismuth and Cadmium.* **T. Takamine.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 51–58, Feb., 1915.)—The author has used the method of the crossed spectra of an echelon and a Lummer-Gehrcke plate to examine the structure of certain sets of lines in the spectra of these elements. A vacuum tube with a Wehnelt kathode as

used by Wali-Mohammad, served as the source of light. The measurements of the satellite separations, in general, agree with those of previous investigators. These results are included in the paper, which is, moreover, illustrated by photographs of the resolved spectra. C. S. G.

694. *High-frequency Spectra.* **I. Malmer.** (Phil. Mag. 28. pp. 787–794, Dec., 1914.)—The author here endeavours to follow experimentally the two K-series further on in the periodic system than hitherto effected by Moseley [Abs. 467, 1249 (1914)], and has examined the series of elements Y—Ag, where Moseley has measured one wave-length only, Cd—Sb, and Ba—Ce. The results are given in tabular form, and also some interesting curves expressing the function $\lambda^{-\frac{1}{2}}$ as a function of the atomic number N. The results lead the author to suggest as a possibility that such an anomaly may be possible as that an element may have different atomic numbers in different series. G. W. DE T.

695. *Spectra of Helium and Hydrogen.* **J. W. Nicholson.** (Nature, 94. p. 642, Feb. 11, 1915.)—It is generally, but incorrectly, assumed that Bohr's theory of the spectra of He and H would be proved if the existence of certain faint components close to the H lines were established, and disproved by the failure of exhaustive research to find them. E. J. Evans [Abs. 551 1915)] has discovered and measured these components. But their isolation, although a great step in our knowledge of H or He, does not prove them to be He lines, and, moreover, their existence would follow, not from Bohr's theory only, but from the existence of the 4686 series, whatever its interpretation. The author considers the only method of proving or disproving Bohr's theory to be by interference measurements of the first four or five lines in the 4686 series, from which the value of Rydberg's constant can be calculated exactly, and compared with Curtis's value for H. The lines have not yet been measured accurately enough for this. G. W. DE T.

696. *Interference Phenomena to be expected when Röntgen Rays pass through a Diatomic Gas.* **P. Ehrenfest.** (K. Akad. Amsterdam, Proc. 17. pp. 1184–1190, April 28, 1915.)—Friedrich has found that a beam of Röntgen rays passing through yellow wax and other amorphous solid substances gives interference rings on a photographic plate placed behind it [Abs. 1290 (1913)]. He has discussed two possible explanations of the observed phenomena. The problem is considerably simpler in the case of the passage of Röntgen rays through a diatomic gas. Whether the experimental difficulties can be surmounted remains to be seen; if this should be so, new data might be obtained in this way on the situation of the atoms in the gas molecule.

Let homogeneous plane Röntgen rays fall on an isolated diatomic gas molecule. Both atoms emit secondary waves which interfere in the whole space. Considering the interference at an arbitrary point P of a plane E which lies normal to the direction of incidence of the Röntgen rays, it is found that the mean intensity varies as $1 + (\sin 2\pi\rho/2\pi\rho)$, where $\rho = (2a/\lambda) \sin \frac{1}{2}\phi$, $a$ is the distance apart of the two atoms, considered as points, $\lambda$ the wave-length of the Röntgen rays, and $\phi$ the angle between the direction of the incident rays and the line joining the molecule to the point P. If now the effect is considered for the whole mass of gas, it is found that the dark rings on the plane E will, except for a slight diminution in sharpness, continue to be represented by the above expression. The difficulties in the way of experimental realisation of these rings are very great, but possibly not insurmountable. The best experimental conditions are suggested. A. W.

697. *Corpuscular Radiation Liberated in Vapours by Homogeneous X-radiation.* **H. Moore.** (Roy. Soc., Proc. 91. pp. 337–345, May 3, 1915.)—In a former paper [see Abs. 682 (1914)] it was shown that for carbon and oxygen the number of corpuscules liberated from an atom by a beam of X-rays is the same whether the atom is in combination or not. This conclusion has been extended to the cases of nitrogen, sulphur, and chlorine, a close agreement being obtained for each of these in two or three different combinations respectively; corroboration has also been made of the values previously given for carbon and oxygen. The following table shows that the atomic corpuscular radiation is approximately proportional to the fourth power of the atomic weight.

| Substance and Atomic Weight. | Atomic Corpuscular Radiation (A.C.R.). Air = 1. | (Atomic Wt.)$^4$ × $10^{-4}$. | $\frac{(\text{Atomic Wt.})^4}{\text{A.C.R.}}$ × $10^{-4}$. |
|---|---|---|---|
| Carbon (12) ......... | 0·2 | 2·07 | 10·3 |
| Nitrogen (14) ...... | 0·34 | 3·84 | 11·3 |
| Oxygen (16)......... | 0·64 | 6·55 | 10·4 |
| Sulphur (32)......... | 10·9 | 104·8 | 9·6 |
| Chlorine (35·5) ... | 14·7 | 158·8 | 10·8 |

From the observations of Barkla and Simons [Abs. 900 (1912)] and Barkla and Philpot [Abs. 1709 (1913)], it is shown that the coefficient of absorption of a beam of X-radiation in a gas is proportional to the quantity of electronic radiation liberated from the gas; hence the X-radiation absorbed by an atom of a given element will also be proportional to the fourth power of the weight of the absorbing atom. Recent experiments by Bragg and Pierce [Abs. 75 (1915)] show that a similar law holds for elements in the solid state.

A. B. W.

698. *Intensities of X-ray Spectra.* **D. L. Webster.** (Phys. Rev. 5. pp. 238–243, March, 1915.)—According to W. H. Bragg [Abs. 1340 (1914)], if X-rays of a given frequency are reflected from a crystal at the angle $\theta$, the intensity of the reflection is given by the equation—

$$I_\theta = \frac{A(1 + \cos^2 2\theta)}{\sin^2\theta}\,\epsilon^{-B\sin^2\theta}.$$

The exponential factor $\epsilon^{-B\sin^2\theta}$ has been found by Debye to result from displacements of the atoms from their normal positions by heat vibrations. The factor $(1 + \cos^2 2\theta)$ is the one originally deduced by J. J. Thomson for any kind of secondary X-radiation. The object of the present paper is to account for the factor $\sin^2\theta$ in the denominator. By considering mathematically the cases of reflection of (1) a long train, and (2) a short train of waves from a crystal, the author concludes that the factor $\sin^2\theta$ signifies that the train of waves emitted by an atom in the radiator is short compared with the distance the rays travel through the crystal. Experiments are to be undertaken as a further test of some of the theoretical points raised. A. B. W.

699. *Secondary Effects of X-rays.* **P. T. Weeks.** (Phys. Rev. 5. pp. 244–248, March, 1915.)—An explanation is given for a peculiar effect produced by secondary X-radiation. The relative intensifying effect from different metals placed behind a photographic plate when exposed to X-rays of various penetrating powers has been investigated. A. B. W.

**700.** *Absorption of Homogeneous β-Rays.* **R. W. Varder.** (Phil. Mag. 29. pp. 725–734, May, 1915.)—The object of the experiments described was to determine the form of the absorption curve when very homogeneous β-rays pass through Al, and to test whether there is any simple relation connecting the absorption with either the velocity or the energy of the β-ray. Using a magnetic field to separate a complex beam of β-rays from RaEm (and its subsequent products), homogeneous pencils over a wide range of velocities could be used in the absorption measurements. By working with direct and reversed magnetic fields the effects due to γ-rays could be eliminated. In the case of Al, after a small thickness had been traversed, an approximately linear relation was found to exist between the ionisation and the thickness of the Al screen. Curves are given showing the variation with the velocity of the rays. By producing the linear part of the curve to cut the "thickness" axis, the approximate "range" of the β-particle in Al could be obtained. A curve showing the range of β-rays in Al at various velocities is given, this question being also treated from a mathematical standpoint.

The fact that the Al absorption curve is approximately linear must result from a chance balancing of the opposing effects of scattering and diminution of velocity. Using absorbing substances (like paper) in which the scattering is less important, the absorption curve approaches more and more to a Bragg α-ray curve: using substances like Sn and Pt, in which the scattering is large, the curves are convex towards the origin. A. B. W.

**701.** *Lead and the End Product of Thorium.* II. **A. Holmes** and **R. W. Lawson.** (Phil. Mag. 29. pp. 673–688, May, 1915.)—In Part I. of this paper (Ibid. 28. p. 823, 1914) it was shown from the Ur, Th, and Pb contents of 4 series of radio-active minerals: (1) That the Pb/Ur ratio is remarkably constant in minerals of the same age, and varies in proportion to the geological age of minerals of different ages, so that RaG may be regarded as stable; (2) that thorium-lead does not tend to accumulate with time—*i.e.* thorium E is an unstable product; (3) that the Pb/Ur ratios may be used as before and with greater certainty for the determination of geological time.

The present paper gives a more complete treatment of a method outlined recently [see Abs. 1686 (1914)]. On the assumption that the total lead present in the minerals is made up of three constituents: (*a*) Ur-lead (radium G); (*b*) Th-lead (ThE); (*c*) original lead—it has been shown how the results obtained can be applied to find the half-period of ThE. This is given as approximately $10^8$ years. From considerations of the Geiger-Nuttall law connecting the ranges of α-particles with the period of the product emitting them, it has been suggested that the disintegration of ThE may be accompanied by the loss of a β-ray, so that the resulting product would be an isotope of bismuth. Evidence is given, however, which suggests that this isotope is unstable.

The evidence of atomic-weight determinations, a table of which is given for lead from many radio-active and non-radio-active sources points to the stability of RaG, and the instability of ThE.

Experiments to throw light on the stability of actinium lead are suggested, as well as methods of attacking the question of the end product of Act, incidentally throwing light on the atomic weight of actinium. It is shown that atomic-weight estimations can now be used to correct the crude determination of the age of a mineral by its present Pb and Ur contents. Corrections have to be applied for original lead which may be considerable (as in Ceylon thorianite), and for a small equilibrium amount of thorium lead. A. B. W.

**702.** *Radio-activity of Minnesota Soils.* **J. C. Sanderson.** (Am. J. Sci. 39. pp. 391–397, April, 1915.)—A method has been devised by which the Ra-content of a soil may be determined from a sample of about 50 lbs. This method, together with the thorium method previously described [see Abs. 1686 (1911)], was used to determine the radio-active content of 13 typical Minnesota soils. The results of the Ra and Th measurements, as well as some data with regard to fertility, origin, etc., of the soils, are tabulated. A wide range of variation in the Ra-content of the soils is shown, this variation being probably due to varying ratios of "free" emanation to total emanation produced in the soil. This in turn depends on the superficial area of the particles and on the hygroscopic properties of the soil. Without exception, the very fertile soils were found to be richer in Ra and Th emanations than were the soils of inferior fertility. A. B. W.

**703.** *Thorium Content of the Earth's Crust.* **J. H. J. Poole.** (Phil. Mag. 29. pp. 483–489, April, 1915.)—This series of experiments was undertaken with the view of supplementing previous work by Joly on the radio-activity of terrestrial surface materials [Abs. 435 (1913)]. The same composite rock mixtures as were used in the previous series of experiments were also used in these. The method of procedure was to fuse the mixture with a mixture of the alkaline carbonates. The melt was then treated with water and filtered, the residue being dissolved in distilled water containing pure HCl. The solution obtained was set aside for some days to allow the thorium disintegration products time to grow, as some of them are lost in the process of getting the rock into solution. The thorium content was determined by boiling off the thorium emanation in a constant stream of air, which then passed through an ordinary gold-leaf electroscope that was standardised with a thorianite solution of known strength. The composite rock mixtures may be roughly divided into three classes: acid, intermediate, and basic. Some results obtained for some miscellaneous rocks are also given. The thorium content is found to decrease as we pass from the acid to the basic rocks. In this respect the thorium content resembles the radium content. However, there is no exact numerical proportion existing between the two. There is nevertheless a certain amount of evidence that the ratio of radium to thorium also increases as we pass from the acid to the basic rocks, and for certain rocks this ratio seems to remain fairly constant. It is also remarkable that the value of the ratio always lies within such narrow limits. In only three or four cases does it lie outside the range $1{\cdot}3$ to $2{\cdot}7 \times 10^{-7}$. This range is perhaps not narrow enough to justify us in assuming that there might be any genetic connection between uranium and thorium, but that the ratio is as constant as it is, is certainly a remarkable fact. On the supposition that the composition of the lithosphere approximates to that of a diorite or andesite the average thorium content of the earth's crust would be about $1{\cdot}6 \times 10^{-5}$. But this value is obtained only from surface materials; it may be that the thorium content is different at some distance below the surface. Giving a weight to each result proportional to the number of rocks in the powder from which the result was obtained, it is found that the mean thorium content of the acid rocks alone is $2{\cdot}08 \times 10^{-5}$ and for the basic rocks $0{\cdot}56 \times 10^{-5}$. The general mean for the experiments was $1{\cdot}50 \times 10^{-5}$. In these results the miscellaneous rocks are neglected, and the values are obtained from 86 acid, 48 intermediate, and 56 basic rocks. If the simple arithmetic means are used, slightly different values are obtained: acid 2·13, intermediate 1·50, and basic 0·51. The corresponding general mean is $1{\cdot}38 \times 10^{-5}$. A. W.

## HEAT.

**704.** *Specific Heat of Compounds.* **J. Duclaux.** (Journ. de Physique, 4. pp. 472–480, June, 1914. Paper read before the Soc. franç. de Physique, June, 1913.)—From a study of the values of the specific heat of a large number of organic liquids, the author shows that the specific heat of a compound can be calculated additively according to the composition of the substance with an error not greater than that of the experimental determination. A. F.

**705.** *Ratio of Specific Heats of Mixtures of Gases.* **A. Leduc.** (Comptes Rendus, 160. pp. 338–341, March 15, 1915.)—For a mixture of gases whose partial pressures in terms of the whole pressure are expressed by $r_1, r_2 \ldots r_n \ldots$, the author obtains the relation

$$\frac{k}{\gamma-1}=\sum\frac{k_n r_n}{\gamma_n-1},$$

where the $r$'s denote the ratios of specific heats, and the $k$'s are specified functions of the pressure and temperature.

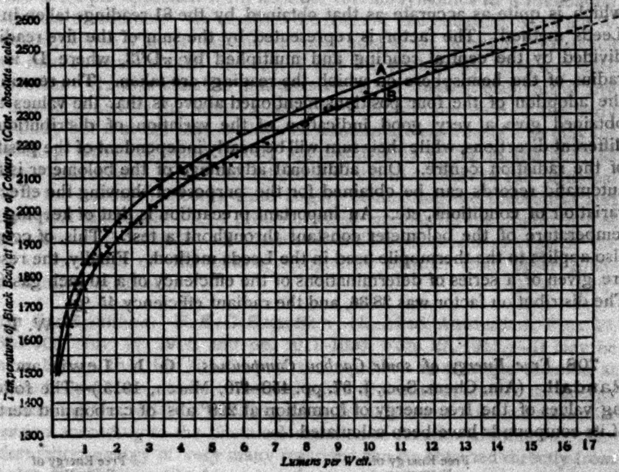
Applying this to moist air, in which $r = 0{\cdot}02$ and $\gamma_2 = 1{\cdot}315$, $\gamma_1$ being $1{\cdot}405$, it is calculated that $\gamma = 1{\cdot}397$.

The results are to be applied to the speeds of sound in gases. [See Abs. 1187 (1898).] *Errata*, Ibid. p. 574, April 26, 1915. E. H. B.

**706.** *Estimation of High Temperatures by the Method of Colour Identity.* **C. C. Paterson** and **B. P. Dudding.** (Phys. Soc., Proc. 27. pp. 230–259; Disc., 260–262, April, 1915.)—Optical pyrometry has so far been confined to matching the intensity of the light emitted by a black body with that emitted by the body under observation. In this way the "black-body temperature" (different from the true temperature) has been found. If now the *colours* of the lights be compared instead of their *intensities*, then, provided the observed body radiates as a grey body (*i.e.* one whose radiation in every wave-length of the visible spectrum is strictly proportional to that of a black body), identity of colour will indicate equality of temperature, and hence the true temperature of a body may be found by comparing it with a body whose colour at any temperature is known. This is the method introduced by the authors, who employ an electric lamp (with either carbon or tungsten filament) previously calibrated against a black body as a comparison body for temperature determinations. The relation between the temperature of this lamp and its efficiency (lumens/watt) has been found to be accurately represented by the equation, $\log_{10}(L/W) = A - B\log_{10}T - 185\log_{10}(1 + 155/T)$, where L/W is the efficiency of the lamp, T its absolute temperature in deg. C., while A and B are constants, being for carbon filaments 21·51 and 4·58 respectively, and for tungsten 28·81 and 5·1. The degree of approximation to which this equation fits the observations is shown in the Fig. where curve A represents the results for 5 carbon, and curve B those for 7 tungsten lamps of variously prepared filaments.

The actual colour match is made in a Lummer-Brodhun photometer head, the change of efficiency being produced by varying a resistance in circuit with the lamp. Numerous determinations by this method of the temperature of melting platinum gave a mean value of 1750° C. using a carbon lamp, and 1770° C. with a tungsten lamp. The agreement of these results with the generally accepted values shows that Pt radiates very approximately as a grey body within the visible spectrum. The determinations by this method of filament temperatures, too, agree well with the results obtained by previous observers with the usual optical methods. It has been found that the colour-identity method of determining filament temperatures is practically independent of the cooling at the ends of the filament of an ordinary lamp, at any rate to the order of accuracy claimed (about 1 %). It is found, finally, that the colour of the Violle standard of light (melting Pt) is the same as that of a carbon lamp operating at $2\cdot6_5$ lumens/watt (approx. 3·8 watts per mean horiz. candle).

In the *discussion*, **A. P. Trotter** objected to the use of the term "white light" for black-body radiation at *any* temperature, while **A. Campbell** suggested that for melting-point determinations, instead of melting the standard strip itself it would be better to employ a tungsten strip heated up until a speck of the body under investigation began to melt. **E. H. Rayner** thought that the sensitiveness of the method might be increased if coloured glasses—first a red and then a blue—were put in front of the eye after a colour match had been obtained. In reply to a question of **J. S. Dow**, the **Authors** stated that it had been found that as a general rule metal-filament lamps were selective in favour of the visible spectrum *as a whole*, and behaved as grey bodies within that region. J. W. T. W.



**707.** *Measurement of Efficiencies of Heat Radiators by Bolometric Method.* **W. A. Bone, H. L. Callendar, and H. J. Yates.** (Roy. Soc., Proc. 91. pp. 245-254, April 1, 1915.)—The Leeds method for the determination of the radiant efficiencies of such radiators as gas fires consists of a measurement of the "distribution factors of the radiator, *i.e.* the ratio of the total hemispherical radiation to that over a central equatorial area. From a measurement of this latter the total radiation within the hemisphere may then be expressed in kilo-calories per hour, and the ratio of this to the total net heat developed by the combustion of the gas in the fire per hour then gives the radiant efficiency of the fire. This distribution factor is determined by means of a thermopile, and the normal intensity is measured with a Smith radiometer. There are certain disadvantages attending the use of these instruments, and this has led the authors to propose the use of a Langley bolometer specially designed to secure constancy and robustness in preference to quickness of action. The form finally adopted is described in the paper. By comparing it in the laboratory with a radio-balance, an instrument of this type can be directly calibrated to give the intensity of the radiation in absolute measure. For flat-surfaced radiators the authors consider that four readings taken at 60° along the equator and meridian from the central position are, together with a reading at this centre, sufficient to give a value for the distribution factor which is quite as accurate as that obtained by the 81 readings taken in the Leeds method. The factor is represented by the sum of the five readings divided by the central reading and multiplied by $\pi D^2/3$, where D is the radius of the hemisphere on which the readings are taken. The reason for the adoption of the four positions mentioned above is that the values thus obtained give a very good indication of the variation of distribution in different directions, while their sum will be nearly independent of the position of the radiation centre. One additional advantage of the bolometer is that automatic records can be obtained for the purpose of showing the effect of variation of conditions, etc. An important precaution is that of keeping the temperature of the bolometer constant throughout a test. This, of course, also applies to the thermopile used in the Leeds method. Finally, the results are given of a series of determinations of the efficiency of a 10-inch gas fire. The distribution factor was 28·36, and the radiant efficiency 45 %.

J. W. T. W.

708. *Free Energy of some Carbon Compounds.* **G. N. Lewis** and **M. Randall.** (Am. Chem. Soc., J. 37. pp. 458–470, March, 1915.)—The following values of the free energy of formation at 298° abs. of carbon and certain of its compounds have been calculated :—

| | Free Energy of Formation. | | Free Energy of Formation. |
|---|---|---|---|
| Diamond ......... | 520 gm. cals. | $HCO_3^-$ ............ | −140,140 gm. cals. |
| CO .................... | −32,560 „ | $CO_3^-$ ............ | −126,130 „ |
| $CO_2$ ................ | −94,360 „ | $CH_4$ ............... | −12,800 „ |
| $H_2CO_3$ (Aq) ...... | −148,970 „ | $COCl_2$.............. | −45,380 „ |

A. F.

709. *The van der Waals Formula (and the Latent Heat of Vaporisation).* **T. C. Sutton.** (Phil. Mag. 29. pp. 593–599, April, 1915.)—The author points out that the methods of calculating latent heats of vaporisation used by Mills and Young [Abs. 1606 (1905)] and by Applebey and Chapman [Abs. 1286 (1914)] are essentially the same. The agreement between the two series of calculated latent heats gives a delicate test of association in a liquid.

A. F.

710. *Kinetic Theory of Perfect Gases.* **E. Bouty.** (Journ. de Physique, 4. pp. 450–472, June, 1914.)—The author continues his general discussion of the laws of gases [Abs. 911 (1914)]. Great stress is here laid upon the author's

definition of the "mean path." This term has, the author says, often been left undefined in elementary courses. The author restricts the use of this term to the mean length (mean of the lengths) of molecular path between two consecutive collisions. L. H. W.

**711.** *Stability of Thermodynamic Equilibrium, and Statistical Mechanics.* **A. Schidlof.** (Archives des Sciences, 89. pp. 25–46, Jan., 1915.)—The utility of statistical mechanics in accounting for phenomena which have not proved amenable to classical thermodynamic theory is now generally admitted. J. W. Gibbs, and, more recently, H. Einstein, have given very wide generality to the theory of statistical mechanics, and freed it from the special models which figured so largely in its development. But this general theory is based upon very recondite considerations and elaborated by long and difficult trains of reasoning which fail to convince many physicists who are quite able to follow ordinary thermodynamics. The author here attempts to make a simple approach from abstract thermodynamics as a foundation to statistical mechanics. He assumes the truth of the equation, $S = k \log W + \text{constant}$, which Planck has shown must hold if we admit the existence of any relation between the entropy, S, and the probability W of any state of a system. He also assumes that the state of the smallest elements of any body is determined by the same variables as determine the state of the body as a whole; but that the laws of thermodynamics are rigorously true only for the smallest elements, being merely approximations so far as the body as a whole is concerned. The assumptions are shown to lead to the principal results of the statistical theory, while largely eliminating the theoretical and mathematical difficulties. The procedure also emphasises the importance of the question of the stability of thermodynamic equilibrium as regards the choice of methods of determining Avogodro's number from observations of statistical fluctuations. G. W. de T.

**712.** *Gas Equilibria.* **F. E. C. Scheffer.** (K. Akad. Amsterdam, Proc. 17. pp. 695–708, Nov. 27, 1914, and pp. 1011–1026, Feb. 27, 1915.)—It may be taken as known that the situation of the equilibrium of a gas reaction at a definite temperature can be calculated when at that temperature the energy of reaction and the variation in entropy free from concentration for molecular conversion according to the chemical equation of reaction are known. The transformation energy of very many reactions can be obtained directly from Berthelot and Thomsen's tables; but the transformation entropy is usually obtained, not directly, but from the chemical equilibria. To determine chemical equilibria from heat data, therefore, we require either direct determinations of the transformation or another way of calculating equilibria using exclusively separate quantities of gas. E.M.F.'s of gas cells are examples of such direct determinations, since the temperature coefficient of the e.m.f. is a measure of the transformation entropy; for many types of reaction this method is inapplicable, *e.g.* for dissociation in molecules or the atoms of the same kind. The general calculation of chemical equilibria therefore requires the determination of the entropies of the separate gases or of the algebraic sum of the entropies of a gas equilibrium from the constants of the substances. The thermodynamic entropy of a gas as usually defined involves an undetermined constant, but when defined as a function of the probability of the condition a definite value is obtainable, but will vary according to the definition of the probability, as is exemplified in the differing expressions derived by Keesom [Abs. 288 (1914), 86 (1915)], Sackur [Abs. 463 (1913)], and Tetrode [Abs. 1389 (1912)]. These differences do not cancel out from the algebraic sums, and so, provided the experiments be sufficiently accurate, must make it possible to determine which is the true expression. The author proceeds to test these various expressions and also van der Waals, junior's, formula for the "equilibrium gas constant" of gas reactions by a detailed comparison of data from the literature of the subject. The simplest gas equilibrium $AB \rightleftarrows A + B$, in which A and B may be of the same or different kinds, is briefly discussed in its general form, and the special case $I_2 \rightleftarrows 2I$ is treated in detail. The gas entropy expressions, being derived exclusively from gas properties, leave solid entropy out of account, so that its determination from $S = k \log W$ remains a separate problem. But O. Stern [Abs. 1688 (1914)] has determined gas entropy with respect to the solid state at $T = 0$ as zero condition. The test of Stern's expression provides a criterion for the validity of Nernst's heat theorem, *e.g.* in the iodine equilibrium the algebraic sum of the solid entropies at $T = 0$ is not zero, as Nernst's theorem makes it, but about —7. But here, besides $\Sigma S_{solid}$, the moment of inertia of the iodine molecules is to be determined. Stern objects to the small value of the latter derived from the index of refraction, but the author maintains that at the high temperatures involved (about 1000° C. and upwards) the chance of solid may be put at zero, so that the test remains outside the question of the validity of the heat theorem. If now $k \log W$ has been taken as the gas entropy (call this the gas scale for the entropy), then the solid entropy may be determined either from $dS = dQ/T$, or by applying $k \log W$ to the solid state. The latter, necessarily involving some hypothetical constitution of the solid, must be highly arbitrary. If, however, the common assumption is made that the solid entropy at $T = 0$ is zero, then the entropy of other states can be determined from $dS = dQ/T$. This the author calls the scale for solid, and considers it need not coincide with the gas scale, and if it does for one substance, need not for all. It is a question for experiment, and he considers the only available data to be: (1) The theoretical derivations of Stern's gas entropy; (2) the vapour-pressure line of mercury; (3) the calculation for iodine of

$$\sum_{\text{Solid } T = 0}^{\text{gas}} \frac{dQ}{T}.$$

Stern's derivations agree closely with the author's calculations, and so seem to point to an identity between the two scales. But the validity of Stern's expressions is dependent on the truth of his conception of the structure of a solid, and so his results do not provide a rigorous proof. Apart from Stern's work, the author's conclusions may be summarised as follows:—(1) From the mercury pressure line the entropy of solid mercury seems about zero at the absolute zero-point of the gas scale; (2) from caloric data the entropy of solid iodine ($I_2$) at $T = 0$ is about —7; (3) from the author's calculations the radius of inertia of $I_2$ is about a fifth of the mean molecule radius derived from the refractive index; (4) when the former radius of inertia is used the test of the vapour-pressure line of iodine yields for the entropy of solid iodine a value of about —7, in agreement with (2); (5) the available data do not provide any criterion of the validity of the heat theorem; (6) in agreement with (3) calculations by Mandersloot give smaller moments of inertia than would agree with the mean molecule radii as determined from the index of refraction, internal friction, and *b*-values of the equation of state.

An expression for the dissociation constant in the equilibrium

$2AB \rightleftarrows A_2+B_2$ is obtained by applying the consideration of van der Waals, junior, containing three moments of inertia. Calculations for the cases, $A = H$, and $B = I$, Br, Cl, respectively, give for their ratios values agreeing with those derived from the mean molecular radii. This conclusion was arrived at by Sackur as a rough approximation. The author calls attention to its agreement with van der Waals, junior's, expression, in which the vibrations of the atoms are allowed for. G. W. DE T.

**718.** *Planck's Formula and Classical Electrodynamics.* **D. L. Webster.** (Am. Acad., Proc. 50. pp. 131–145, Jan., 1915.)—Poincaré has pointed out [Abs. 841 (1912)] that, in common with every formula giving only a finite amount of energy per unit volume in the radiation field, Planck's formula for black-body radiation involves the assumption of some discontinuities in the process of absorption and radiation. Planck's assumption is inconsistent with classical electrodynamics, and we should have to abandon the electrical explanation of inertia and many other generally accepted theories, and create a whole new theory of optics. The assumption even of two sets of oscillators, one in accordance with classical electrodynamics, the other in accordance with Planck's assumptions, to account for both optical and thermal phenomena, does not seem feasible. For a very small percentage of the former would give large deviations from Planck's law, and the presence of the Planck oscillators would not admit of the well-known relations such, *e.g.*, as that between absorption and dispersion. Moreover, unless the percentage of each class of oscillators for each frequency were exactly the same for every substance at each temperature, the distribution of energy in the spectrum of a cavity would depend on the substances contained in its walls, which would contradict the second law of thermodynamics. The author here attempts to replace Planck's assumptions by others less subversive of physical theory, and in this way arrives at a theory based upon Parsons' *magneton*, a ring of negative electricity of a diameter perhaps 1/10 that of a hydrogen atom, revolving on its axis with a velocity of the order of that of light, and free to move in a sphere of continuously distributed positive electricity. Parsons has shown, in a paper not yet published, that by a tendency to grouping themselves in eights, the magnetons give a foundation for the periodic table of the elements, and moreover, that they explain the exceptions as well as the tables, and account surprisingly well for many other chemical phenomena. The theory is more complex than the classical electron theory. For there are the attraction of the positive electricity and the mutual electrostatic repulsions of the magnetons, tending to stability; the magnetic attractions of the other magnetons, tending to reduce stability; and perhaps still other repulsions by these others, proportional to some inverse power of the distance higher than the second, and therefore having a strong tendency to promote stability. The combined effect must, of course, be a stable equilibrium.

The possible modes of vibration will be a rigid displacement of the magneton and a disturbance of the electricity round it. Assuming, for convenience in the mathematical investigation, that the charge-centre and mass-centre move together, and that any number of waves may be superposed without mutual disturbance, the intra-atomic forces are divided into five classes. Four of these are in accordance with classical theory, the necessary divagation being introduced in the assumption of a tendency of the internal tendency of the magneton to transfer energy from the oscillation of the electricity on it to the steady current round it. A small deviation from Parsons' assumption, which would not appear to affect the explanation of observed facts given by his theory, makes the equilibrium of the ring, under the magnetic attractions and non-electrostatic repulsion between them, so stable that, for visible and ultra-violet frequencies, the motion of the charge-centre is due chiefly to the electrical oscillation on the ring, and very little to the motion of the ring as a whole. In the infra-red the motion of the atom will change the whole character of the oscillation. This non-classical assumption interferes with no experimental facts, and the classical theory of propagation of light is shown to be fully reproducible from this model.

After briefly discussing the serious difficulties of Planck's hypotheses the author shows that Planck's law and other experimental results may be accounted for by assuming that, when the energy stored in the magneton reaches any integral multiple of $k\nu$, the internal mechanism of the ring may start another oscillation, larger than the absorbing one, and that this emitting oscillation will maintain a constant amplitude, deriving its energy in some way from the steady current, until the excess energy stored in the magneton has been radiated, and its total energy is reduced to a standard amount. The probability $\eta$ of starting to radiate at any particular multiple of $k\nu$ is the same as in Planck's theory. This mechanism is shown not to be too big for the atom, as is that of Planck. The assumption made is unpredictable, and admittedly opposed to the expectations based on existing knowledge of physical phenomena, which would be more in accordance with a scheme for obtaining the quantum from the dimensions and charges of different parts of an atom. Its justification, the author claims, lies in its ability to correlate experimental facts which are inconsistent with these other schemes. For the author shows that it leads to Planck's law, and is inconsistent with classical dynamics only in the internal structure of the magneton, and so correlates the phenomena of heat-radiation with those of optics and electricity, while also giving an account of the laws of photoelectric and photo-chemical phenomena. Finally, being based on Parsons' magneton, it correlates all these phenomena with those of chemical combinations.

G. W. DE T.

714. *Failure of Equipartition and Specific Heat Determination.* **J. G. Stewart.** (Phil. Mag. 28. pp. 748–758, Nov., 1914.)—Equipartition is generally assumed for gases when there is no chemical change. Although theoretically true only under static external conditions, high molecular velocities are supposed to bring about equilibrium more rapidly than any possible changes. But energy absorbed in expansion is derived from rotational as well as translational motions. The former must be transformed into the latter to affect the pressure; and this must take time, as experiment confirms.

Regnault's constant-pressure method of determining the specific heat of gases at high temperatures is unaffected by this, the gas at inlet and outlet having constant pressure and temperature. The constant-volume method should be affected, and experiment confirms this. Dugald Clerk's indicator diagram method is affected also, but can be so arranged that the effects on compression and expansion largely cancel out. The lag behind equilibrium due to the time required for change of rotational into translational energy accounts for many observed phenomena, which strongly confirms the existence of such lag.

G. W. DE T

715. *Energy Distribution for Natural Radiation.* **S. Lees.** (Phil. Mag. 28. pp. 794–798, Dec., 1914.)—The paper contains some formal analyses sug-

gested by a paper of Rayleigh's (Phil. Mag. 27. p. 466, 1889). The results obtained indicate that in the random impulses that constitute natural radiation, we may be led mathematically to a certain distribution of energy in the spectrum, provided that the time-interval T contains a sufficiently large number of any periods considered. Thus between the values $p$ and $p + dp$ we shall have an amount of energy $\epsilon[f(p)]^2dp/8T$ per unit volume. If we identify this with the steady distribution obtained by experiment, we are led to suppose that the harmonic analysis of a component of, say, the electric force X over a sufficiently long time T, must yield ultimately results of a steady type in such a way that, to take an example developed in the paper, if $X = \int_0^\infty f(p)\cos(pt + \beta)dp$, where $\beta$ may be a function of $p$, and X is assumed finite with a finite number only of discontinuities within the time-interval $0<t<T$, then $[f(p)]^2$ tends to become proportional to T, the time over which the original disturbance is analysed. The exact character of $f(p)$ cannot, of course, be determined by the considerations adduced.

G. W. de T.

716. *Radiation Hypotheses of Planck and Einstein.* **P. Ehrenfest** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 17. pp. 870–873, Dec. 24, 1914. Supplement No. 37 to the Communications from the Phys. Lab., Leiden. Phil. Mag. 29. pp. 297–301, Feb., 1915.)—The authors first give a simplified deduction, from the theory of combinations, of the formula for the number of ways in which N monochromatic resonators may be distributed over the various degrees of energy, determined by the series of multiples 0, $\epsilon$, $2\epsilon$... of the unit energy $\epsilon$, when the resonators together must each time contain the given multiple $P\epsilon$. This formula forms the basis of Planck's radiation-theory. It is pointed out in an appendix that this permutation of the elements $\epsilon$ is a purely formal device, just as the permutation of the elements 0 is; and that the attribution of a physical meaning to the formal device of distributing P energy elements over N resonators, is a mere misunderstanding. It is shown to be in absolute conflict with Planck's radiation-formula, and that it would lead to that of Wien. Planck's formal device cannot be interpreted in the sense of Einstein's light-quanta.

G. W. de T.

717. *A Classification of High-temperature Physical Problems.* **E. F. Northrup.** (Met. and Chem. Eng. 13. pp. 147–150, March, 1915.)—This stimulating article, which deals with the subject under 26 brief headings, was written for the double purpose of assisting the author in the selection of the problems which he would attack, and to call attention to the immensity and fruitfulness of this field of investigation. No short abstract is possible.

L. H. W.

## SOUND.

718. *Æolian Tones.* **Rayleigh.** (Phil. Mag. 29. pp. 433–444, April, 1915.)—In what has long been known as the Æolian harp, a stretched string, such as a pianoforte wire or a violin string, is caused to vibrate in one of its possible modes by the impact of wind; and it was usually supposed that the action was analogous to that of a violin bow, so that the vibrations were executed in the plane containing the direction of the wind. A closer examination showed, however, that this opinion was erroneous and that in fact the vibrations are transverse to the wind. Further, it is not essential to the production of sound that the string should take part in the vibration, and the general phenomenon, exemplified in the whistling of wind among trees, has been investigated by Strouhal (1878) under the name of *Reibungstöne.* In Strouhal's experiments a vertical wire or rod attached to a suitable frame was caused to revolve with uniform velocity about a parallel axis. The pitch of the æolian tone generated by the relative motion of the wire and of the air was found to be independent of the length and of the tension of the wire, but to vary with the wire's diameter (D) and with the speed (V) of the motion. Within certain limits the relation between the frequency (N) and these data was expressible by $N = 0{\cdot}185\ V \div D$...(1), the centimetre and the second being units.

Other refinements are here considered and finally the following formula is given: $ND/V = 0{\cdot}195(1 - 20{\cdot}1\nu/VD)$, where for air at about 20° C. the kinematic viscosity is $\nu = \mu/\rho = 1806 \times 10^{-7}/0{\cdot}00120 = 0{\cdot}1505$ c.g.s. For water at 15° C., $\nu = 0{\cdot}0115$.

The formation of vortices in the fluid flowing past the wires is discussed and some preliminary experiments are described.

Further experiments are still, however, admittedly desirable. E. H. B.

719. *Thermophones.* **P. de Lange.** (Roy. Soc., Proc. 91. pp. 239–241, April 1, 1915.)—Introduces an invention somewhat like a telephone, in which, however, the telephone receiver is replaced by a Pt-wire. The decrease and increase of heat in the Pt-wire takes place isochronically with the vibrations in the microphone. The air surrounding the Pt-wire is thereby immediately heated or cooled in accordance with the increase and decrease of heat in the wire, and, if that air is retained within a closed compass of the cover, the expansions and contractions will be noticed as sound. E. H. B.

720. *Piano-players.* **G. H. Bryan.** (Nature, 95. pp. 131–134, April 1, 1915. Paper read before the Roy. Inst., March, 1915.)—Considered from an engineering point of view, the modern piano-player is a marvel of human ingenuity. The feature which distinguishes it from its early predecessors is the element of controllability, which leaves the interpretation of the music largely to the choice of the performer. Of recent years, however, personal control has been supplemented by accent devices, automatically operated, the construction of which is essentially an engineering problem. The details of the mechanism and action involved in the "blow" on the key are then discussed, and suggestions made as to the management of the "player" and the drill to be used for children seeking to acquire dexterity in the use of the "player" instead of practising scales and five-finger exercises. E. H. B.

**721.** *Ear Protection against Artillery Sounds.* **C. V. B[oys].** (Nature, 95. p. 181, April 1, 1915.)—Those who have associated with our gunners must have noticed how often they suffer from deafness. The sudden access of pressure in the neighbourhood of a gun at the moment of firing imposes so great a strain on the drum of the ear that deafness is a usual result. The increase in pressure in the modern gun, and the high pressure still remaining when the shot reaches the muzzle, make the conditions more serious than they used to be until comparatively recently. Not only those who are near the gun when fired, but those also in the neighbourhood of bursting shells, bombs, or explosives, are liable to suffer in a similar way even if they are not otherwise damaged.

A. Mallock, who has for many years conducted investigations in connection with artillery, has invented an "ear defender," the object of which is to protect the drum of the ear from very sudden and violent access of pressure, while still allowing the minute variations produced by ordinary sounds to be received with but little loss. The defender consists of a containing piece made of ebonite and shaped like the pieces used in the game of Halma, and of about the same size. The ball end is very finely milled and it is made to fit the passage of the ear, there being five sizes, differing very slightly in dimensions in this part, to suit different people. The piece is pierced centrally by a hole 5 mm. in diam. at the small end, and gradually enlarging towards the other end, where it opens into a recess 1 cm. in diameter. Into this are fitted in order a flat-ring washer, a disc of fine wire gauze, a very thin flat-ring washer, a delicate diaphragm, a very thin flat-ring washer, a disc of fine gauze, and a flat-ring washer.

When a pair of defenders is placed in the ears, the thin diaphragms, untouched except near their edges, where they are held, are free to take up aerial vibrations and to transmit it to the ear passage. Thus ordinary sounds are heard with little loss. When, however, the violent impact due to gunfire or explosion in the neighbourhood occurs, the diaphragm is brought up against the wire gauze, by which further movement is checked, also the injurious increase of pressure. Hence the ear is defended. E. H. B.

**722.** *Form and Constitution of Water-jets under the Action of Sounds.* **P. Cermak.** (Ann. d. Physik, 45. 1. pp. 75–104, Aug. 14, 1914.)—Experimental work with instantaneous photographic records of the effects obtained. Single jets and tones are used and also afterwards two or more jets and several tones. The photographs show in some cases the small drops between the large ones; in others the drops are in pairs, threes, or fours, while some show the change from continuous jets to drops. E. H. B.

**723.** *Propagation of Sound in Air with regard to the Effect of Gravity.* **M. Cristofori.** (N. Cimento, 8. pp. 189–202, Sept., 1914.)—This paper is wholly of a mathematical nature, and the author, as a result, formulates the following law: For equality of other conditions, taking account solely of gravity, the effective intensity of the vibrations in the vertical ascending propagation, tends to be reinforced. The factor by which it increases, $\epsilon$, referred to the vibrational intensity which it has at sea-level, is expressible as the fourth root of a number which ranges between 1 and 1·256 for the altitude range 0 to 5900 m. We have thus very approximately $\epsilon = [1/(1 - \alpha z)]^{1/4}$, where $\alpha = 0{\cdot}0000889$. L. H. W.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

**724.** *Electromagnetic Inertia and Atomic Weight.* **J. W. Nicholson.** (Phys. Soc., Proc. 27. pp. 217-228; Disc., 229, April, 1915.)—It is generally believed that the experiments of Kaufmann and Bucherer have finally demonstrated that the mass of a swift $\beta$-particle, and therefore of any electron, is purely of electromagnetic origin, and in accordance with the formula of Lorentz. This mass is accordingly, on the supposition that a slowly-moving electron is spherical, of the form $\alpha e^2/ac^2$, where $\alpha$ is a numerical factor, quoted usually as 2/3, and $e$ and $a$ are the charge and radius of an electron, $c$ being the velocity of light in free ether. Modern theories of the nature of positive electricity in an atom—theories to which we are led inevitably by many converging lines of experiment—demand also a discrete structure for positive electricity. It must exist in portions equal to $e$ or multiples of $e$, and of a size not greater than that of the electron, but of much greater mass. The similarity of these portions to electrons suggests that their mass is purely electromagnetic, and if so it should be subject to the same formula, which, as dependent on velocity, unfortunately cannot be tested, by virtue of the difficulty of giving a sufficiently high velocity to such comparatively heavy bodies as $\alpha$-particles.

Rutherford's model of the hydrogen atom contains only a single electron and a single *positive electron.* But a hydrogen atom has the mass of 1835 electrons, according to the best estimates, and therefore the positive electron is equivalent on this view, in spite of the identity of charge, to 1834 electrons in mass. Since the radius of the electron is of the order $10^{-13}$ cm., that of the positive electron is of the order $0{\cdot}5 \times 10^{-16}$ cm., and this greater concentration is responsible for the increase of mass.

Most of the properties of the hydrogen atom, and, in fact, all that are explicable on this basis, would, however, remain unchanged if the nucleus of the atom were not a positive electron but an aggregate of nuclei and electrons whose total charge amounts to $+e$. There are many indications that this is a more correct view, and some of them are here reviewed briefly, the references being to the researches and views of Fajans, Soddy, Fleck, J. J. Thomson, Aston, Moseley, Buisson and Fabry, and of Bohr.

A mathematical theory is then developed for the mass of two or more charges, which results in the following formulæ for the masses of charges $e$ of radius $a$ and at distance $\lambda$ apart :—

$$\text{Mass of two charges} = (2/3c^2)(e_1^2/a_1 + e_2^2 a_2 + 3e_1e_2/\lambda)$$

$$\text{Mass of any number of charges} = \frac{2}{3c^2}\left\{\Sigma\frac{e_r^2}{a_r} + 3\,\Sigma\Sigma\,\frac{e_r e_s}{\lambda_{rs}}\right\}$$

Some of the conclusions in the paper are admittedly dependent on controversial points, for they involve the not generally accepted doctrine that the atomic weights of thorite lead and ordinary lead are different. Again, they involve the conclusion of Rutherford and Darwin that the law of force even at a distance of $10^{-13}$ cm. from the centre of the nucleus is still that of the inverse square. This conclusion, like the calculations in the paper, would be overthrown if it could be proved that appreciable magnetic forces had their seat in the nucleus of an atom, as one school of physicists maintains.

E. H. B.

**725.** *Atomic Numbers and Atomic Charges.* **F. Sanford.** (Phys. Rev. 5. pp. 152–158, Feb., 1915.)—Concludes that though the electrical properties of the elementary atoms are in some manner closely related to their respective serial numbers, it is not probable that these numbers represent in all cases the magnitudes of the electro-positive charges of the sub-atoms. [See Abs. 708 (1913), 768 (1914).]

E. H. B.

**726.** *Dielectric Losses in Steady and Alternating Electric Fields.* **G. L. Addenbrooke.** (Phys. Soc., Proc. 27. pp. 291–303; Disc., 303–304, April, 1915.)—After references to former work [Abs. 1730 (1912)] tables are given showing an intimate connection between the losses in steady and alternating fields, and that the one can be predicted from the other to a first approximation. Curves of the losses from ¼ ∾ to 40 ∾ per sec. are given: above 8 to 12 ∾ both for "good" and "poor" dielectrics, these become rising straight lines. The salient features lie below about 16 ∾. The formula $a + bn$ is applicable above about 8 ∾, but not below. The $a$ constant is always larger than and bears only a very indefinite relation to the steady voltage loss. For liquid dielectrics the ratio of the steady to the alternating loss is less than with solids. There is a great difference in the comparative ranges of the losses, *e.g.* 1 to 1,800,000 in a steady field and 1 to 1100 in an alternating field.

I. W.

**727.** *Electrification of Surfaces as affected by Heat.* **P. E. Shaw.** (Phys. Soc., Proc. 27. pp. 208–215; Disc., 215–216, April, 1915.)—The paper deals with the anomalous electrical behaviour of various substances when subjected to heat, *e.g.* a glass rod rubbed with silk is normally left positively electrified, but if the rod be passed through a Bunsen flame, or heated in an electric furnace, and then allowed to cool, it will be found on again rubbing with the silk that the glass becomes negatively electrified. The reversal in sign, here called abnormal, can be produced (*a*) in a clear or smoky Bunsen flame, (*b*) in a blowpipe flame, (*c*) in a benzene or alcohol flame, (*d*) over any flame if enough time is allowed, (*e*) in an electric furnace, where heat reaches the surface affected by radiation through air. Of some 18 pairs tested only one, namely "indiarubber/sealing wax," failed to give the abnormal effect, but as rubber was the softest substance used and the general law is that hard substances show the effect well and soft ones badly, more delicate means would probably have detected the effect. Discharge of any charge, + or —, which may be on the surface in every one of the above cases precedes the production of the abnormal state. The latter can be removed from the surface by continued rubbing with silk, cotton, etc., or better, by rubbing the surface with the hand. It is not removed by melting (in the case of glass) or by annealing, or by the action of water, or by lapse of time: it is a surface effect only. An unstable intermediate condition is found after the surface has been rubbed for some time. In this condition the surface may act normally when rubbed in one way, abnormally when rubbed otherwise. This state does not last. All solids which can withstand flame for a second or two appear to act, as does glass, in the above ways. The action is seen best in vitreous silica, and less well in wood, metals, slate, paper, ebonite, etc. In all cases the substance rubbed is, when normal, above indiarubber in the ordinary frictional list, but below it when abnormal. The cause of the abnormal effect cannot be attributed to any organic substance deposited by a flame, since the effect is producible without flame, nor to the removal of a layer of condensed water-vapour since after immersion in water the effect remains on the surface, nor to the deposition by flame of water on the cold surface since flame is not necessary; also it seems unlikely to be caused by heat removal of the air film since it remains on the surface 12 days or more after the time of production, the solid being in the air during the whole time. The action must be regarded, therefore, as having its seat in the surface layers of the solid. Great agitation and subsequent strain caused by heat produces a negative charge on the excited surface, and the process of rubbing, especially in the case of soft bodies, would relieve the state of strain and the surface would be restored to normal. H. H. Ho.

728. *Nature of Large Ions in the Air.* **J. A. Pollock.** (Phil. Mag. 29. pp. 514–526, April, 1915.)—The large ions in the air, which were discovered by Langevin in 1905, have a mobility which at constant atmospheric pressure is a function of the relative humidity only. At standard pressure the mobility varies from 1/1250, when the humidity is 4 %, to 1/3440 when the pressure is that of saturation. These ions do not exist in dust-free air, so the picture most readily formed is that of a collection of water molecules surrounding a dust particle, the whole being electrified by the attachment of a small ion. The ion thus affords an interesting example of the adsorption of water-vapour at a rigid surface.

A thermodynamic argument, based on the relation between mobility and relative humidity, leads to the conclusion that the adsorbed moisture is in the liquid state with a latent heat and density little different from those of water.

The order of magnitude of the diam. of the ion, as calculated on usual kinetic theory lines, varies from 3 to $4 \times 10^{-7}$ cm. according to the atmospheric conditions. [See next Abs.] E. H. B.

729. *New Type of Ion in the Air.* **J. A. Pollock.** (Phil. Mag. 29. pp. 636–646, May, 1915.)—A description is given of certain characteristics of an ion in the air with a mobility intermediate between that of the small gas-ion and that of the large ion of Langevin. The mobility is found to depend on the water-vapour pressure rather than on the relative humidity. Both the intermediate and large ions exist in the air at the same time provided the vapour-pressure is below 17 mm.; above this pressure only the large ion is found.

On the whole evidence it seems probable that the intermediate ion consists of a rigid nucleus enveloped by a dense atmosphere of water-vapour. The mass of the ion becomes greater as the vapour-pressure increases, until at a critical pressure the adsorbed fluid assumes the liquid state, and the aggregation develops, by the rapid condensation which ensues, into the large ion of Langevin. The intermediate and large ions thus appear to form a somewhat striking illustration of Trouton's discovery of the two modes of condensation of water-vapour on rigid surfaces. [See preceding Abs.] E. H. B.

730. *Lightning.* **V. Monti.** (Accad. Lincei, Atti, 23. pp. 839–841, Oct. 29, 1914.)—The author draws various deductions from a comparison of the condi-

tions of a lightning discharge with those determined experimentally for brush discharges (compare Przibram, Wien. Rev., 1904; Schmidt, Meteorolog. Zeitschr., 1907). T. H. P.

## DISCHARGE AND OSCILLATIONS.

731. *Asymmetric Emission of Photo-electrons from Thin Films of Platinum.* **O. Stuhlmann, Jr.** (Phys. Rev. 4. pp. 195–207, Sept., 1914.)—It is well known that the photoelectric effect of thin films of metals deposited on quartz depends on the thickness of the film and whether the film is on the side of the quartz facing the source (incident effect, I) or on the side away from the light (emergent effect, E). The ratio of the photoelectric currents $E_e/I_e$ is greater than unity for films of Pt $10^{-7}$ cm. or less in thickness, and greater than unity for thicker films. Robinson [Abs. 1030 (1913)] has shown the same is true for the max. velocities, $E_v$ and $I_v$, of the electrons emitted. Recently Partzsch and Hallwachs [Abs. 1825 (1913)] showed that films of Pt on quartz whose thickness is less than $10^{-6}$ cm. absorb, when illuminated through the quartz plate, 1·5 to 1·4 times as much of the incident light as when the illumination falls directly on to the Pt. The conclusion drawn is that these differences are great enough to account for the ratio $E_e/I_e$ being greater than unity. The variation in absorption gives no explanation of the ratio $E_v/I_v$ being greater than unity for films $10^{-7}$ cm. or less in thickness. The author now repeats Robinson's observations with an apparatus of essentially the same design. His results confirm those already obtained, the ratios $E_v/I_v$ being, however, a little larger, and a distinct maximum is found to exist for both the incident and emergent energies at a thickness $10^{-7}$ cm. If from the data of Partzsch and Hallwachs the curve relating absorption of light with film thickness is plotted, no such pronounced maximum exists as would account for the sudden increase in current and velocity. T. H.

732. *The Thermionic Current.* **A. S. Eve.** (Nature, 95. p. 174, April 15, 1915.)—If a carbon-filament lamp is silvered inside, and a Pt-wire through the side of the glass makes electric connection with the belt of silver, it is easy to experiment with the thermionic current, using a telephone receiver with one terminal to the Pt-wire and the other to the water mains. With an alternating current at 110 volts a loud note is heard, depending on the frequency of alternation. With a direct current from a dynamo there is sufficient variation in the voltage to obtain a sound just audible at 100, loud at 110, very loud at 130, and it might be described as an uproar at 140 volts. At 142 volts the uproar is replaced by dead silence, which continues up to 165 volts, as high as the lamp could stand. The explanation, based on Langmuir's work, is as follows:—The thermionic current does not increase with the temperature, according to Richardson's law, unless the vacuum is of a high order. With a moderate vacuum the volume-charge between the filament and silver causes the thermionic current to remain at a value nearly constant as the temperature is raised above a certain value. The thermionic current begins by obeying Richardson's law, and then later approximates to a steady value. Thus at low voltages variations of voltage cause variations of temperature and consequent fluctuations of thermionic current, heard through the telephone. Above 140 volts, however, for the particular lamp in question, a change of voltage and of temperature produces no change of current, and hence no sound can be heard in the telephone. It is possible that this method may prove very convenient for testing the electron emission from various substances in different gases, and it suggests a method of measuring a high vacuum. A. E. G.

733. *Effects of Different Gases on the Electron Emission from Glowing Solids.* **F. Horton.** (Roy. Soc., Proc. 91. pp. 322–337, May 3, 1915.)—The original theory of the origin of electron emission from glowing solids, which is based on the theory of metallic conduction, has recently been subjected to criticism. The critics maintain that the emission occurs as a result of chemical actions between the hot kathode and the surrounding gas or between the constituents of the kathode. In a recent paper [see Abs. 1867 (1914)] the author has shown that the latter view leads to results which are not always supported by experiment. The work described here was designed to test further the theory that electron emission is due to chemical action. It consists in studying the ionisation from a Nernst filament heated in various gases of different chemical affinities for the material of the kathode. The apparatus is the same as that already used, the filament being heated by an alternating current from a transformer, and its temperature determined by a Féry pyrometer. The anode consists of two parallel Pt-plates, connected together, fixed at equal distances on opposite sides of the filament. The arrangements were such that the mid-point of the filament was earthed. Measurements of the thermionic current in air, oxygen, nitrogen, and hydrogen were made. In each case the variation of current with gas pressure under a constant p.d. between anode and kathode was determined, and also the variation of current with p.d. for constant gas pressures. The results are given in the form of a comparison of the ionisation produced in air with that produced in the second gas, as different filaments give slightly different thermionic currents. It is shown that the thermionic current is independent of the gas. At low pressures the current under definite conditions is practically identical in all four gases used; at higher pressures the currents under similar conditions vary, but the large currents which are obtained at certain gas pressures, especially with hydrogen, are the result of "ionisation by collision," not of different electronic emission from the kathode filament. Oxygen and hydrogen differ so widely in their chemical affinities for an oxide kathode that the equality of electron emission in the two gases is evidence that the electrons are not produced by chemical action between kathode and surrounding gas. It has been shown that the presence of hydrogen seems to produce a genuine increased emission from a Pt-kathode which appears to be brought about by the absorption of gas by the Pt. The results obtained here suggest that the great emission from a lime-covered Pt-kathode in hydrogen might be due to the effect of the hydrogen on the emission from the Pt supporting the lime. To test this the lime was supported on a Nernst filament and tested in air and hydrogen. The results indicate that the emission from lime is the same in air and hydrogen under these conditions. In the case of a Pt-kathode H. A. Wilson has shown that the hydrogen dissolves in the Pt and does not under ordinary circumstances combine with it to form a compound, so that it is improbable that the increased emission from Pt is due to chemical action. With a substance like lime or the oxides of a Nernst filament by which hydrogen is not absorbed, the electron emission is unaltered by the presence of this gas. T. H.

734. *Photoelectric Effect.* III. **O. W. Richardson** and **F. J. Rogers.** (Phil. Mag. 29. pp. 618–623, April, 1915.)—Richardson and Compton have published data giving the relative photoelectric efficiencies of Pt, Al, Na, and Cs for light of different wave-lengths when a given amount of energy falls on them. The measurements are now reduced to absolute values by finding the capacity of the electrometer used in the current measurements and cali-

brating the thermopile by using a source (a standard glow-lamp from the Bureau of Standards) radiating energy of known density. The results are given in coulombs/calorie.

The caesium used was very inefficient photo-electrically in spite of its being highly electro-positive. It is probable that it was much fatigued before the observations were made.

The results are compared with those given by Werner and by Pohl and Pringsheim. T. H.

**735.** *Photoelectric Constant and Atomic Heat.* **T. C. Sutton.** (Phil. Mag. 29. pp. 784–786, May, 1915.)—The author of this paper points out the remarkable regularity which is noticed when the divergences of the atomic heats of elements are compared with those of the photoelectric constants. Thus, when the atomic heat is high, the photoelectric constant is low, and *vice versa*. A table is given in support of these observations. It has been found that the value of the product (atomic heat) × (photoelectric constant) is remarkably constant and equal to 35·5. The author gives a few suggestions in explanation of this constancy in the product. It is suggested that both phenomena are due to the "ultimate discontinuity" of energy as postulated in the quantum theory. "When a limited number of quanta are absorbed by a molecule, the various properties of the molecule are not necessarily affected to the same extent—as some quanta may function in one way, some in another. For any particular metal, the proportion that affects the atomic heat is related to the proportion that affects the photoelectric constant; and if the nature of the metal is changed, this relation is one of inverse proportion." A. B. W.

**736.** *Ionisation Potential of Mercury Vapour.* **F. H. Newman.** (Phil. Mag. 28. pp. 753–756, Nov., 1914.)—An experiment is described to find the smallest p.d. through which an electron must fall before it is able to ionise a molecule of Hg by collision. The electrons were produced by raising a lime-coated Pt-wire to a state of incandescence, and by means of a p.d. applied between two electrodes, causing these electrons to acquire such a velocity that they ionised the molecules of the vapour with which they collided. The positive ions thereby produced were attracted to a negatively charged disc which was in electrical connection with a Dolezalek electrometer. It was found that, at 79° C., with the Hg-vapour at a pressure of about 0·1 mm., the smallest velocity which the electrons must possess in order that they may ionise the Hg molecules is that produced by their passage through a p.d. of 5 volts. This value agrees well with that obtained by Franck and Hertz [Abs. 1583 (1914)], viz. 4·9 volts. But their value is a still closer approximation to the theoretical value of 4·84 volts deduced from the quantum hypothesis. G. W. DE T.

**737.** *Ionisation by Impact applied to Experiments by Franck and Hertz.* **B. Davis.** (Phys. Rev. 5. pp. 118–125, Feb., 1915.)—Develops a theory of ionisation by impact and applies it to the current curves obtained with a mesh or grid in the experiments of Franck and Hertz in 1913. [See Abs. 1319 (1913).] **H. W. Farwell.** (Ibid. pp. 149–151, Feb., 1915.)—A supplement to the theory by B. Davis on the same subject. [See also Abs. 295 (1907).] E. H. B.

**738.** *Emission and Absorption of the Residual Gas in Röntgen Tubes, and the Emission of X-rays.* **P. Cardani.** (Accad. Lincei, Atti, 24. pp. 105–119, Jan. 30, 1915.)—The author's experiments, carried out with the objects of explaining the phenomena accompanying the extreme rarefaction of Röntgen tubes and of ascertaining the conditions necessary for their most effective action, lead to the following results. The Al electrodes of the tubes, after contact with the air, contain in an occluded form an appreciable quantity of gas which is not released spontaneously at the ordinary temperature, even under the most complete rarefaction, but is given up when a discharge is passed. At a high temperature the gas is also liberated, but here too the liberation is facilitated by passage of the discharge; the amount of gas thus set free increases with rise of temperature. The occluded gas experiences very great difficulty in reaching the surface of the electrodes, even under the influence of high temperature and rarefaction, and the electrodes may consequently undergo superficial exhaustion and the pressure remain constant during the passage of the discharge for some days, so long, indeed, as the occluded gas in the deeper layers fails to compensate the exhaustion when it reaches the surface; when, however, such compensation does occur, emission of gas recommences on the discharge being passed. When superficial exhaustion has been established, the electrodes will re-absorb, under the action of the discharge and at the ordinary temperature, the gas previously emitted at the high temperature. The course of the emission and of the subsequent absorption vary with the particular conditions of exhaustion of the superficial strata of the electrodes.

In order, therefore, that a tube may become stable for the emission of X-rays, it is necessary that the gas occluded in the whole mass of the electrodes shall be in permanent equilibrium, even when the tube is traversed by the discharge, with the external gas, and for that pressure at which the emission of X-rays is a maximum; it is the establishment of this condition of equilibrium of the whole of the occluded gas with the external gas which determines the prolonged operation required in the construction of a Röntgen tube.

That the gas emitted from the electrodes is not air is indicated by the appearance of the tube during the passage of the discharge and is confirmed by examination of a tube into which a small quantity of dry air was introduced after the rarefaction had been pushed to its utmost limit.

The curves of emission of X-rays vary continuously with the pressure and depend essentially on the surface conditions of the electrodes from which the discharge starts; only when the exhaustion is very complete does the emission follow a constant law, that is, the X-rays always begin at the same pressure. T. H. P.

**739.** *Effect on Radio-telegraphy of Atmospheric Ionisation.* **H. Nagaoka.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 408–412, Oct., 1914.)—A consideration of the various ways in which atmospheric ionisation originating primarily in solar action is produced leads to the conclusion that the state of the ionised layer accounts for a large proportion of the variability in the transmission of signals which is actually observed, including the better transmission at night, the beneficial result of increasing the wave-length during the daytime, and the fact that meridional transmission is better than along the parallels of latitude. G. W. de T.

**740.** *Effect of Solar Eclipse on Wireless Transmission.* **H. Nagaoka.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 428–430, Dec., 1914.)—The author here applies the arguments of his former paper [preceding Abs.] to explain the effect observed during solar eclipses. He shows that the alteration in atmospheric ionisation from interception of sunlight would cause the ionised layer to rise gradually higher until totality is reached. The change will be confined to a narrow region in the umbra, and last for a few minutes only, totality being over before any large change in ionisation occurs. The portion of layer in penumbra will be slightly concave towards the earth, causing a slight corrugation above the region of totality. By his previous argument the intensity of signals will be weakened as the eclipse begins, pass through a minimum, rise rapidly to a maximum, and then slowly decrease. The record obtained by the Gesell. für drahtlose Telegraphie [Telefunken-zeitung No. 6, p. 89, 1912] resembles the latter half of such a curve. It is noted that any strong atmospheric electric disturbance occurring at the time may be expected to mask the effect of the eclipse. G. W. DE T.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**741.** *Wavelength-sensibility of Crystals of Metallic Selenium.* **L. P. Sieg and F. C. Brown.** (Phys. Rev. 4. pp. 507–516, Dec., 1914.)—The authors have studied the wavelength-sensibility curves of a number of crystal forms of Se and have obtained curves which can explain most of the variations found in Se. These crystals have directive axes in the property of light action as well as in the property of light transmission and crystal structure. Light-sensitive Se seems not to be a simple substance but a complex mechanism and the complexities appear to arise from more or less elementary constituents. Thus the atom of Se cannot be the sole unit in the mechanism acted upon. There is evidence that the variation of the properties of light-sensitive Se is inherent in the crystals that compose it, and that these crystals by virtue of their form and position determine the properties of the selenium mass. This conclusion is supported by a study of the wavelength-sensibility curves which has been made by the authors. Each crystalline form has a distinctive characteristic curve. Moreover, the same crystal gives different curves when illuminated along different axes. The action of polarised light was also investigated, but further experiments are required with this before definite conclusions are reached. J. J. S.

**742.** *Influence of Annealing on the Characteristics of Light-sensitive Selenium.* **E. O. Dieterich.** (Phys. Rev. 4. pp. 467–476, Nov., 1914.)—In the investigation of selenium cells it was found that the sensibility curves differed widely, some showing a maximum in the red, others a maximum in the blue. The crystallisation of the Se took place under different conditions in the different samples. Further observations were made which are described in this paper. The method followed in making the cells is detailed: and it is shown that the resistance and the shape of the wavelength-sensibility curve of Se cells can be controlled by varying the process of annealing. The location of the maximum in the wavelength-sensibility curve can be controlled by a variation in the conditions under which the Se in the cell is crystallised. It is shown that the temperature variations play the most important part. The various types of cells can be explained by assuming the presence of various kinds of crystals, or different positions of the same kind of crystals in the cells. The temperature at which one kind is formed may not be favourable for the formation of another kind, hence the production of the different types of cells. J. J. S.

**743.** *Production of Isolated Crystals of Selenium.* **F. C. Brown.** (Phys. Rev. 5. pp. 286–287, March, 1915.)—Details are given as to the physical conditions necessary for the production of isolated crystals of Se of the hexagonal and monoclinic systems. In this article photographs are reproduced and the dimensions given of crystals of the monoclinic system; similar photographs of crystals of the hexagonal system having been given in a previous paper [see Abs. 1879 (1914)]. So far as is at present known, the electrical, the photoelectric, and the electro-mechanical properties of crystals of the two systems do not show any marked differences. Experiments to determine the refractive index of Se, a conducting substance, are to be carried out. A. B. W.

**744.** *Physical Properties of Selenium.* **F. C. Brown.** (Phys. Rev. 5. pp. 167–175, Feb., 1915.)—The author's experiments indicate that when a selenium crystal is illuminated at certain points the conductivity of the entire crystal is increased. When pressure is applied to the crystal, it is only that part of the crystal which is under pressure that is altered. Electrical forces alter the conductivity only of that part directly under the forces, and, moreover, the influence is exerted only in the direction of the electrical force. From these observations it is concluded that light-action has to do with a mechanism essentially different from that of electrical stresses or mechanical stresses. Hence the author formulates certain notions about the structure of a selenium crystal, and suggests that the physical phenomena which are noted in the case of selenium may be merely accentuated, just as the magnetic properties are accentuated in iron. J. J. S.

**745.** *Electric Conduction and Thermoelectric Action in Metals.* **E. H. Hall.** (Am. Acad., Proc. 50. pp. 67–108, 1914.)—Thermal capacity of the electrons seems to be a necessary condition for thermoelectric action. It is assumed that through a considerable range of temperature the number of free electrons per cm.$^3$ of a metal is represented by the formula $n = K_n T^\nu$, where $K_n$ and $\nu$ are constants and T is the absolute temperature, and that R in the equation $pv = RT$, reckoned for a single electron, is represented by the formula $R = K_r T^\rho$, where $K_r$ and $\rho$ are constants, R being less at ordinary temperatures for an electron than for a gas molecule.

Electric conduction is supposed to be maintained in part by free electrons, (B), acting like gas molecules in the interatomic spaces of the metal, and in part by other electrons, (A), which pass directly from atom to atom, perhaps during collisions, without taking part in the gas-pressure action of the (B) electrons. Formulæ are reached for the specific conductivity and the coefficient of the Thomson-effect in a metal, on the supposition that these properties are dependent entirely on the free electrons, and it is found that these two expressions are either incompatible with each other or not in agreement with observed facts. The conclusion is reached that the free electrons are necessary for the phenomena of thermoelectric action, but play an unimportant part in electric conduction. Expressions are obtained for the Peltier-effect and for the difference of virtual potential at the junction of two metals, virtual potential being due partly to electric charge and partly to the specific attraction of metals for the electrons. The value of the net e.m.f. of a thermoelectric circuit appears from the formula to be dependent on the values of T, $n$, $\nu$, and $\rho$ in the system and not on any specific attraction of metals for the electrons.

Change of volume and change of electric resistance in metals on melting are discussed. These quantities are usually of the same sign. In liquid mercury (as has previously been pointed out), rise of temperature without change of volume would produce a decrease of resistance. J. J. S.

**746.** *Superconducting Circuits of Onnes and Ampère's Theory of Magnetism.* **L. Puccianti.** (Accad. Lincei, Atti, 23. pp. 578–582, Jan. 10, 1915.)—The author considers an ordinary circuit immersed in a medium of inductivity $\mu_1$ and having the coefficient of induction $\Lambda_1 = L\mu_1$, a constant current $i$ being maintained in the circuit by a suitable electric motor. An expression is derived for the mechanical work effected by the electromagnetic forces when the circuit passes from the medium of inductivity $\mu_1$ to a second of inductivity $\mu_2$ in any manner whatsoever. It is then shown that when a circuit traversed by an Onnes current, induced in a cooled solenoid without electromotive force, is immersed successively in two different media, the two currents are inversely proportional to the inductivities of the respective media. This conclusion is deduced from the laws of induction and the expression for the intrinsic energy, and is, therefore, independent of any hypothesis concerning the nature of magnetism. On the basis of Ampère's electrodynamic hypothesis, the mutual actions are considered of: (1) two ordinary electric circuits; (2) an ordinary circuit and an Onnes circuit; (3) two Onnes circuits. It is shown that the dependence of these actions on the surrounding medium follows the known laws for electrodynamic actions (direct proportionality to the magnetic inductivity of the medium), electromagnetic actions (independence of the inductivity), and magnetic actions (inverse proportionality to the inductivity) respectively. Thus, according to the electrodynamic theory, Onnes circuits assume the functions of the magnets.

The difference between the electrodynamic and ordinary theories of magnetism consists in the interpretation of the two vectors, B and H, of the magnetic field. In the former B represents the magnetic force, and in the latter the magnetic induction. T. H. P.

**747.** *Conduction of Electricity at Point Contacts.* **A. F. Hallimond.** (Phys. Soc., Proc. 27. pp. 70–77; Disc., 77–80, Dec., 1914.)—The paper relates to the conductivity of "point contacts" when a steady or slowly varying e.m.f. is applied; the effect of high-frequency oscillations is not considered. The results are presented as characteristic or volt-ampere curves for the respective contacts. A form of mirror galvanometer was used by which the characteristic was directly plotted as the path of the spot of light on the screen, the arrangement being of the ordinary rocking mirror type. One coil (of low resistance) was connected as ammeter, the other as voltmeter. Thus the co-ordinates of the deflection were those of the characteristic curve. The behaviour of a typical contact, zincite-tellurium, is first described. The well-known unilateral curve is terminated by a sudden breakdown of resistance, after which the contact has a more symmetrical characteristic of lower resistance at the origin. Results are given which were obtained on examining the characteristics for the 45 contacts possible between 10 chosen substances. The conclusion is reached that the results in all cases are similar to those given by zincite-tellurium. No line could be drawn separating metallic contacts from those in which one or both conductors were crystals. The results obtained are expressed in terms of a series in which the higher member behaves towards the lower as zincite to tellurium.

The series is: zincite, brookite, molybdenite, chromium, galena, inserite, chalcocite, copper, chalcopyrite, tellurium.

The conclusion is drawn that in a contact yielding the unilateral (high-resistance) curve, the resistance lies within the surface of the member standing higher in the series. Rough measurements showed that the weight required in these contacts diminished from about 1000 gm., for zincite, to very light contact for the substances lying near Te, and it is suggested that this gradation in weight determines the relative positions arrived at for the respective substances. J. J. S.

**748.** *Electric Resistance of Metals at Low Temperatures.* **H. Schimank.** (Ann. d. Physik, 45. 5. pp. 706–736, Oct. 15, 1914. Extract from Dissertation, Berlin.)—The resistance curves were obtained for a series of metals down to the temperature of boiling hydrogen. The metals used were Pb, Cd, Au, Ag, Zn, Cu, Co, Ni, Fe, and also the alloy constantan. The validity of the *a*-rule was proved and for $a < 0{\cdot}03$ was found accurate to $\frac{2}{10}$ths of a degree Centigrade. The value of $a$ is obtained from the equation $w_1 = (w_2 - a)/(1 - a)$, where $w_1$ and $w_2$ are the resistances of two different Pt-thermometers at the same temperature and $a$ is the constant in question, which may perhaps be the constant of relative purity or a homogeneity constant. The significance of the constant for resistance thermometry and for the criticism of resistance measurements is shown. By means of this *a*-rule and the extrapolated limiting resistance at absolute zero the observed curves were reduced to a high degree of clearness. A structural change seems to act in the sense of a decrease of purity of the material. The explanation of this phenomenon is sought on the lines of Tammann's theory of crystals and an orientation of the crystal material is assumed as cause, and the conductivity of the crystal is treated as vectorial characteristic.

J. J. S.

**749.** *Contact Difference of Potential of Distilled Metals.* **F. Sanford.** (Phil. Mag. 29. pp. 623–624, April, 1915.)—In some of his experiments Hughes [Abs. 1884 (1914)] observed that after a film of Zn or Bi had been condensed from the vapour upon a very thin film of Pt on a glass plate in a high vacuum, the condensed film was at first much less electropositive to the Pt film than it became after standing for some time, and that the change to the more electropositive condition was hastened by admitting a small quantity of air to the vacuum. The author attempts to explain these effects, by showing that a locally heated piece of glass becomes electro-negative to the colder portions, as in Hughes' experiments the glass must have been considerably heated over the regions on which the metallic films were deposited.

A. B. W.

**750.** *The Coil of Maximum Self-inductance.* **R. E. Shawcross** and **R. I. Wells.** (Electrician, 75. p. 64, April 16, 1915.)—The authors discuss the problem of the self-inductance of a ring coil of rectangular cross-section. For a given thickness and length of wire they draw curves showing how the inductance of the coil varies as the shape of the coil is altered; keeping the ratio of the width to the depth constant. The curves show that in all cases the inductance has a max. value for a coil of definite shape. The use of these curves as a help to designers of choking coils is pointed out. **A. Russell** (Ibid. p. 98, April 23, 1915). Russell states that for a given area of cross-section, the inductance of a ring coil is greater when the cross-section is circular than when it is square. He also states that the inductance of a single-layer coil of given length is a maximum when the ratio of its diam. to its height is 2·4525. A. R.

751. *Wave-form of Current in a Coolidge X-ray Tube.* **R. Bown.** (El. World, 65. pp. 396–397, Feb. 13, 1915.)—A brief description of the Coolidge tube [Abs. 564 (1914)] is given and reference is made to previous determinations in X-ray tubes of the old type [Abs. 1691 (1908)]. The author uses an induction coil, operated either with a Wehnelt or a mercury turbine interrupter, and passes the current through a step-up transformer, the secondary of which is connected to a Duddell high-frequency oscillograph. The transformer allows of the use of a standard oscillograph and makes it possible to obtain large-size records of very small currents. Several oscillograms are given and these indicate that the current through the tube rises rapidly to a maximum and then drops, with a few oscillations, back to zero. The secondary current was about 20 milliamps. I. W.

752. *Silver Voltameter.* **G. A. Hulett** and **G. W. Vinal.** (J. Phys. Chem. 19. pp. 173–192, March, 1915.)—A comparison was made of porous-cup voltameters which differed considerably in size and shape and particularly in the manufacture of the porous cups. It was found that when the porous cups were brought into equilibrium with the electrolyte, as shown by acidity tests, all the voltameters gave results in excellent agreement. When the voltameter bowls containing deposits were allowed to stand filled with water, a progressive solution of the silver was found to take place. This was shown to be due to a galvanic action, and it seems desirable, therefore, to wash the deposits quickly. F. E. S.

753. *Metallic Oxide Resistance-thermometers.* **S. L. Brown.** (Phys. Rev. 5. pp. 126–134, Feb., 1915.)—Somerville's experiments [Abs. 739B (1912)] on the variation of resistance of metallic oxides with temperature are quoted. The author has constructed resistance thermometers in which the element is a rod of fused metallic oxide. The solid rods were obtained by melting the oxides in porcelain tubes. These tubes may be retained during use or may be ground off on an emery wheel. The oxides used were $Cu_2O$, $Fe_3O_4$, and ZnO. The first two gave the most satisfactory results. Soldering of connections is impossible, but good results were obtained by clamping two pairs of leads against the ends of the oxide rods; one of these pairs carried the exciting potentiometer current and the other pair formed the usual potential leads. The variable contact resistance between the oxide and the exciting current leads is eliminated if a balance is obtained with the standard resistance immediately after each balance is obtained with the oxide element. The temp. range was about 0° to 500° C. For temperatures up to 200° C. the resistances were placed in an oil bath, the temp. of which was measured with a mercury thermometer. For higher temperatures an electric furnace and a platinum-iridium couple were used. The magnetite thermometer is about 16 times as sensitive as the platinum thermometer at 0° and about 8 times as sensitive at room temperatures. At 300° C. it is about twice as sensitive. I. W.

754. *The Vacuum Guard-ring and its Application to the Determination of the Thermal Conductivity of Mercury.* **H. R. Nettleton.** (Phys. Soc., Proc.

27. pp. 129–148; Disc., 148, Feb., 1915.)—A specially constructed vacuum vessel heated at the top by steam and cooled at the bottom by flowing water, is used to find the thermal conductivity of mercury. The vacuum guard-ring is so efficient that the temperature gradient as measured by a single thermo-junction carried by a cathetometer is probably not in error to the extent of 1 in 500. The Searle modification of the continuous flow method is used to measure the heat. Measurements made on different days agree to within about 1 %. The mean value obtained for the thermal conductivity was 0·0196 between 35° C. and 45° C. The remarkable linear nature of the temperature gradient obtained within the vessel, the cross-section of which was very uniform, over the larger range of temperature 35° C. to 65° C. indicated that there is no diminution of thermal conductivity with rise of temperature. All temperature measurements were made with iron constantan thermo-couples, special care being taken to eliminate local thermo-electric effects. A simple arrangement is described for keeping a "cold junction" during the time of an experiment constant to 0·01 deg. C. at temperatures above that of the room. I. W.

## ALTERNATING CURRENTS AND MAGNETISM.

755. *Paramagnetism at Low Temperatures.* **H. K. Onnes** and **E. Oosterhuis.** (K. Akad. Amsterdam, Proc. 16. pp. 917–920, March 26, 1914. Communication No. 139*e* from the Phys. Lab., Leiden.)—Measurements of susceptibility at low temperatures have been continued according to the method already described. The present paper deals with the properties of ferrous sulphate, palladium, and ferric ammonium sulphate (iron alum). The crystallised ferrous sulphate diminishes in susceptibility with rise of temperature from 14·7° abs., the values not corresponding entirely with those previously published. Palladium deviates markedly from Curie's law, the results agreeing in this respect with those of Honda and Owen [see Abs. 1516 (1910), 1113 (1912)]. Iron alum follows Curie's law throughout the whole range of temperature employed. According to Oosterhuis's theory, this would be caused by the great moment of inertia which the molecule of this substance possesses. It may also be explained by Foëx's theory, since the crystal belongs to the regular system. If substances are arranged according to the value of their atomic concentration, in general the deviations from Curie's law at low temperatures seem to appear sooner in substances with a high concentration. For crystals a linear concentration may have to be introduced. [See also Abs. 168 (1914).] G. E. A.

756. *Changes of Electrical Resistance with Longitudinal and Transverse Magnetisations in Iron and Steel.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 34. pp. 259–268, 1913–1914.)—In a previous paper the author described the changes of resistance of nickel when subjected to a combination of longitudinal and transverse magnetic fields [Abs. 162 (1914)]. In the present paper an account is given of exactly similar experiments with iron and steel. In these experiments no evidence is obtained of what others have observed, viz. an *increase* of resistance in low and moderate transverse fields. Grunmach, for example, observed with iron an apparent increase of resistance up to fields of 7000 or 8000 gauss, after which a decrease rapidly increasing in value was obtained. The author doubts the reality of this initial increase of resistance, and the observations of W. M. Jones and J. E. Malam show that when nickel is accurately placed in the transverse field the change of resist-

ance is always a decrease. There is danger of having present an uneliminated longitudinal component, but in the experiments described in this paper this is obviated by the use of ribbons instead of wires of iron and nickel. Tables of the changes of resistance observed are given, and with regard to the influence of a steadily maintained magnetic field upon the changes of resistance due to a cyclically applied field at right angles to the former, the qualitative results are thus summarised :—(1) Under the influence of longitudinal magnetisation the electric resistance of iron and steel is increased, but this increase is notably diminished when the longitudinal magnetising force is superposed cyclically upon a steadily sustained transverse magnetisation. In the highest transverse fields used, the change of resistance due to the superposed longitudinal field was in most cases very small. (2) Under the influence of a transverse magnetisation the electric resistance of iron and steel is diminished, and this diminution becomes markedly greater when the transverse field is superposed cyclically upon a steadily maintained longitudinal field. In certain cases the change of resistance due to the transverse magnetising force was more than doubled when this field was superposed upon the steadily maintained longitudinal field. J. J. S.

757. *Hall-effect in Silicon.* **O. E. Buckley.** (Phys. Rev. 4. pp. 482–490, Dec., 1914.)—Experiments were undertaken to determine whether the wide variations and reversal of sign of the Hall-effect in various specimens of silicon were accompanied by marked variations in the Nernst-effect and resistance. The temperature coefficients of these quantities were also measured to find if any apparent connection existed among them. For this purpose four specimens of silicon of widely varying degrees of purity were used. The Hall-effect, Nernst-effect, and resistance of these four specimens were measured at several different temperatures. It was found that the reversal of the Hall-effect which is connected with a reversal of its thermal e.m.f. is not accompanied by a reversal or peculiarity in magnitude of the Nernst-effect nor by a peculiarity in the resistance. The temperature coefficients of the Hall and Nernst effects were found to be similar, but did not bear any apparent relation to the temperature coefficient of resistance. The extraordinarily large Ettinghausen and Leduc effects in Si reported by Gottstein are not confirmed. The change in resistance of Si in a magnetic field of 10,000 gauss is less than 0·05 per cent. J. J. S.

758. *Change of Lunar Diurnal Magnetic Variation with Lunar Distance.* **S. Chapman.** (Roy. Soc., Phil. Trans. 215. pp. 161–176, 1915.)—Balfour Stewart in 1882 favoured the view which attributed the short-period magnetic variations to currents flowing in the upper atmosphere, under the impulse of electromotive forces caused by the motion of the conducting atmosphere across the permanent terrestrial magnetic field. Later in 1889 and 1907 Schuster drew attention to the possible connection between magnetic and barometric variations [see Abs. 1158 (1908)]. References to tidal action were suggested by Broun's discovery that the amplitude of the lunar magnetic variation is greater at perigee than at apogee in the inverse cube ratio of the moon's distance at these epochs. In 1903 Figee from a discussion of the Batavian magnetic records came to a conclusion differing from that of Broun.

The author re-examines the data supplied by the hourly values of the magnetic elements at the five observatories, Pavlovsk, Pola, Zi-ka-Wei, Manila, and Batavia. They are considered to confirm with reasonable probability the hypothesis of tidal action, and also show that the phase of the lunar magnetic variation at perigee is considerably in advance of that at apogee (by about 30°). Discussion of the seasonal variation of this phase change shows a progression from summer to winter, with maxima at the equinoxes. C. P. B.

759. *Magnetic "Character" Figures: Antarctic and International.* **C. Chree.** (Phys. Soc., Proc. 27. pp. 193–206; Disc., 206–207, April, 1915.)—The paper makes use of magnetic "character" figures "0" (quiet day), "1" (moderately disturbed day), "2" (highly disturbed day) to investigate whether the incidence of disturbance at the base station of the Scott Antarctic Expedition, 1911–12, did or did not accord with the incidence of disturbance in temperate latitudes, since a great difference exists magnetically between stations in moderate and high latitudes, magnetic disturbances within the Arctic or Antarctic circle having shown a persistence and amplitude unparalled in temperate or torrid zones; also whether the "27-day period" could be recognised in the Antarctic data. A very complete set of tables has been given by Simpson and Wright (physical observers of the Antarctic Expedition) and these are included in the paper with "character" figures assigned to each day's records by the author, a comparison being also made with the corresponding international figures published annually at De Bilt. The incidence of disturbance in the Antarctic was found to agree closely with that shown by the international lists, in spite of the fact that the disturbances in the Antarctic were much larger and more persistent than at any of the stations co-operating in the international scheme. The "27-day period" was clearly visible in the Antarctic records both in summer and winter, being as well developed there as elsewhere. In the *discussion*, Birkeland's theory that auroræ and magnetic storms are alike due to flights of electric ions discharged from the sun received considerable attention, and in his reply the **Author** pointed out that Birkeland is not definite on the question as to whether sun-spots are the origin of the ions or not. One reason for associating them with sun-spots is that in sun-spot minima the magnetic disturbances are not pronounced, but what we fail to find is an equivalent excess of disturbance during sun-spot maxima. H. H. Ho.

## RADIOGRAPHY AND ELECTROPHYSIOLOGY.

760. *Action of Repeated Electromagnetic Doses on Magnetic Projectiles in the Tissues.* **J. Bergonié.** (Comptes Rendus, 160. pp. 255–257, Feb. 15, 1915.)—The electromagnet used should be as powerful as possible. The final one employed in the cases here recorded weighed 40 kg., had a special steel core 60 mm. diam. and a magnetising coil taking 8·5 amps. at 110 volts. A fragment of shell 10 gm. in weight and nearly cubical in form, when resting on one of its faces upon a horizontal sheet of glass, is attracted by this electromagnet placed 10 cm. distant. The experiments made with this magnet, upon pieces of shell embedded in the tissues, show that there is no need to be discouraged when no action takes place at first, even when the foreign bodies are known to be magnetic, because it has been established that by repeated doses the make and break of the circuit produces the desired effect. It is shown that a movement of the projectile takes place and its subsequent extraction is rendered very much easier and more certain. A. E. G.

**761.** *Method of Localisation.* **G. G. Blake.** (Röntgen Soc., J. 11. pp. 20–24, Jan. 1915.)—The new method is based upon Burrell's method, which is briefly as follows:—Two small metal cylinders about 8 cm. long and 2 cm. in diam. are placed a short distance apart on the photographic plate; the patient's arm or other part of the body to be photographed is next placed across the plate in any convenient direction. Two exposures are now made without shifting either the patient or the plate, both being taken with the tube at a known distance from the plate. On developing the plate the shadows of the cylinders cross each other with well-defined edges. Lines are now drawn down the edges of these shadows, and the points L and $L_1$ at the intersection of these lines indicate the positions above which the tube was placed. Shadows of the foreign body are also cast upon the plate at D and $D_1$. Lines are now drawn from L to $D_1$ and $L_1$ to D, and the point where these two lines intersect is the exact spot below which the bullet or other foreign body will be found. The chief drawback to this method is the necessity for measuring the height of the tube, which at the best is done very inaccurately. The improvements now suggested are as follows: The two cylinders are embedded in a block of wax 6·5 cm. apart; half-way between them, also embedded in wax, is a short length of knitting needle 10 cm. long; when the block is placed in position on the plate the needle and cylinders stand perpendicular to it. A small wire triangle, either inked or wetted with silver nitrate so that it leaves a mark both of the triangle and of the numbers at its corners on the skin of the patient, is also employed. In practice it does not matter whether the shadow of the foreign body falls within or outside this triangle. With these alterations no preliminary measurements are necessary: the height of the tube is obtained from the finished negative or print. Graphical methods of finding the height of the tube and the depth of the bullet are described in detail. In order to give the surgeon every help possible in marking the exact spot on the patient's skin below which the foreign body will be found, use is made of a very small triangle whose sides measure only 2·5 cm. in order that the whole of the triangle may be marked on the patient, and when the surgeon receives the negatives or prints he also receives a small piece of tracing paper stretched over a small cardboard frame. On this is a tracing, taken from the negative or print, which shows the triangle and also the exact position of the bullet. When several bodies are present, only one plate is necessary, as each foreign body can be located by this method from its two shadows, and its exact position relative to the triangle be found by lines from L and $L_1$. A. E. G.

**762.** *Localisation of Projectiles by Means of a Special Marker.* **F. Menuet.** (Archives d'El. Médicale, 23. pp. 57–67, March, 1915.)—This method, which is a radioscope one, is called the "Contour Method." The special marker takes the form of a girdle which is employed to encircle the part of the body containing the projectile and the method of using it is as follows:—The wounded person is placed between the tube and a fluorescent screen so arranged that the projectile cuts off the vertical rays from the screen. A metallic ring P is placed behind the body in such a position that its shadow on the screen encircles that of the ball, and a similar ring $P_1$ is placed on the front surface of the body so that its shadow coincides with the first ring. Clearly P, the ball, and $P_1$ are in the same straight line. The points P, $P_1$ are marked on the skin with a dermographic pencil. The wounded person is then slightly rotated and two other points $P_2$, $P_3$ are marked on the skin. The ball is then at the intersection of the two lines $PP_1$, $P_2P_3$. To make more certain two other points $P_4P_5$ are obtained in like manner. The belt is then placed round the part adjoining the marks on the skin, and special arrangements are attached to the belt to indicate the exact position of the marks. The back-to-front diameter of the belt is measured and it is then removed and placed in a horizontal plane so as to have the same shape as when on the body. The intersection of the lines joining the three pairs of attachments to the belt then indicate the exact position of the projectile with reference to the back, front, and sides of the part containing it. The position for operating can therefore be easily chosen.

Details of cases in which this method has been employed are given.

A. E. G.

763. *Precise Method for Localising Foreign Bodies.* **E. J. Hirtz.** (Archives d'Él. Médicale, 23. pp. 28–41, Feb., 1915.)—There is an essential difference between the localisation of a foreign body with relation to certain cutaneous marks and the extraction of that body. Some guide is necessary to enable the operator to find the spot desired. It is such an apparatus that is described here. The detailed account is given in the following sections:—(1) Obtaining the radiograph; (2) Obtaining the orthogonal projection upon horizontal and vertical planes; (3) Regulating the special three-way compass; (4) Verification of the exactness of the localisation; (5) Research for the foreign body; (6) Duration of the operation of localisation. The method has been in use for the past 6 years and has yielded excellent results under the most difficult circumstances.

A. E. G.

764. *A Localising Device.* **W. Hampson.** (Röntgen Soc., J. 11 pp. 10–13; Disc., 13, Jan., and pp. 29–40, April, 1915.)—The method is a modification of that introduced by J. Mackenzie Davidson. A scale has now been devised so that an observation of the extent to which the image of the foreign body moves on the screen is sufficient to give at once the depth of the body below the surface. This method admits of great exactness, as it is possible easily to read to fraction of a mm. The complete device is shown diagrammatically, and the method of employing it fully described. The scale method has also the advantage of portability, the scale dimensions being only about 3 in. by 1 in.

A. E. G.

765. *Measurements of the Radiation from the Coolidge and other X-ray Tubes in Clinical Use.* **S. Russ.** (Röntgen Soc., J. 11. pp. 42–47; Disc., 47–50, April, 1915.)—The Coolidge tube bulb is almost completely devoid of air and the kathode stream is provided by heating a flat spiral of tungsten to a white heat by means of a current from a few storage cells; the hardness of the X-rays generated should, therefore, be conditioned by the voltage at which the bulb is run. The measurements are carried out as follows: A small gold-leaf electroscope, with walls of lead 4 mm. thick, is fitted with a thin Al window about 0·1 mm. thick, through which the rays from a bulb distant about 150 cm. were allowed to enter. The tests made are of two kinds: (1) the character of the radiation for different spark-gaps and for several values of the heating current; (2) the yield of X-rays under various conditions. It is found that the radiation is heterogeneous. If the spark-gap be kept constant the character of the radiation varies, but not very much, with the heating currents. A large increase in the yield of X-rays is produced by a small increase in the heating current. There is a relatively larger yield of "hard" X-rays than of "soft" rays when the heating current is increased.

A. E. G.

766. *Table of Coefficients of Enlargement of Radiographic Images employed in Localising Projectiles in the Tissues.* **M. de Laroquette** and **G. Lemaire.** (Comptes Rendus, 160. pp. 453–456, April 6, 1915.)—This table saves time, as it does away with the need of graphical localisation, but it may also be used as a check upon this method. Its construction and method of use are based upon the following considerations:—Under the Röntgen rays the shadows of opaque objects are more or less enlarged and deviated. The enlargement of the image relative to the object is the difference of dimension between the virtual vertical projection of the object and the real image projected on the plate. The deviation is the distance the image is out of the vertical projection. By means of the table it is possible to determine almost at once the distance of objects from the plate or screen, its horizontal dimensions, and its position relative to a mark placed upon the skin. A. E. G.

767. *Search for and Localisation of Magnetic Projectiles by Means of an Electromagnet worked with an Alternating Current.* **J. Bergonié.** (Comptes Rendus, 160. pp. 448–450, April 6, 1915. Archives d'Él. Médicale, 23. pp. 89–107, April, 1915.)—The core of the electromagnet is held close to, but not in contact with, the part of the body in which it is suspected there is a fragment of a magnetic nature. When the magnet is excited it is easy to recognise whether the flesh in proximity to the core is in vibration or not. If any vibration occurs it indicates the presence of a magnetic body. Results of this nature are obtained with fragments less than 5 gm. in weight situated at a depth of more than 10 cm. The point at which the external vibration is a maximum is often the best to make an incision for removal of the foreign body, as it is the point on the surface nearest to that body. By exploring with the finger during the action of the magnet, the vibratory motion is a useful guide to the surgeon. A. E. G.

768. *The Coolidge Röntgen-ray Tube in Medico-surgical Work.* **Belot** and **M. Ménard.** (Comptes Rendus, 160. pp. 450–453, April 6, 1915. Lum Elec., 29. pp. 181–182, May 22, 1915.)—The principal characteristics in the action of this tube are as follows:—When the spiral is not heated, no current passes in the tube whatever may be the p.d. applied (100,000 volts or more). The current always passes in one direction only. The penetrating power of the Röntgen rays produced is determined only by the voltage at the terminals of the tube. Once the tube is regulated, it acts always in the same way. While the tube is in action no fluorescence of the glass is noted. The bundle of rays is homogeneous. The point of impact upon the surface of the kathode is absolutely fixed. The results obtained from the point of view of radiography, radioscopy, and radiotherapeutics tend to prove the superiority of this tube over others usually employed. A. E. G.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

**769.** *Active Nitrogen.* **VI. R. J. Strutt.** (Roy. Soc., Proc. 91. pp. 303–318, April 1, 1915.)—Further experiments made in conjunction with H. B. Baker and partly with Tiede and Domcke [see Abs. 979, 1624 (1914)] suggest a slight modification of the author's views. The nitrogen should not be perfectly pure to give full effect, nor is it essential that any oxygen or oxygen compound should be present to secure a good yield of active nitrogen. Any small admixture of many foreign gases will enormously increase the yield of active nitrogen; the amount of foreign gas required is usually about 1/1000, but the addition of 1/30000th part of methane has already a very distinct effect. The impurity seems to load the electrons in the discharge and thus to alter the character of their impact with the nitrogen molecules. This view is supported by the fact that gases carrying atoms, which are capable of attaching themselves to electrons in the discharge according to J. J. Thomson and J. Franck, such as oxygen, sulphur, chlorine, carbon, promote the formation of active nitrogen, though hydrogen has only a slight effect, whilst argon, helium, and nitrogen itself, which are not able to load electrons, do not promote this formation. The behaviour of mercury is somewhat anomalous. As regards the reactions of active nitrogen it is found that active nitrogen yields nitrides with metallic vapours; the line spectrum of the metal is observed at the same time. When liquid mercury is shaken in active nitrogen, the glow disappears, the mercury turns foul, and mercury nitride is formed; but the mercury spectrum is not seen, whilst it is observed in Hg-vapour. Active nitrogen decolorises a solution of indigo (in sulphuric acid), through which it is bubbled, and acts freely on most carbon compounds (under formation of hydrocyanic acid), even on the pure hydrocarbons of the paraffin series, hexane and pentane and also methane. H. B.

**770.** *Molecular Attraction.* **XI.** *New Relations revealed by representing Internal Pressure as a Negative Pressure.* **J. E. Mills.** (J. Phys. Chem. 19. pp. 257–274, April, 1915.)—Combination of the Clausius-Clapeyron thermodynamical equation for the heat of vaporisation of a liquid—

$$L = dP/dT\,.\,T\,(V - v)/J,$$

with the thermodynamical equation for the energy spent in overcoming the external pressure during the change of volume, $E_E = P(V - v)/J$, gives $P(V - v) = dP/dT\,.\,(V - v) - 31414\lambda$. This equation is applied to the very accurate data obtained by Young for isopentane. If the usual pressure-volume curve be drawn, $P(V - v)$ is represented by a rectangle, corresponding with the work done in expansion from volume $v$ to volume V against the external pressure P. If it is desired to represent $dP/dT\,.\,T\,(V - v)$ by an area, this will have the same base as before, but the pressure ordinate is enormously greater than P. If, now, $T\,.\,dP/dT$ be regarded as representing a total pressure made up of the external pressure and an internal pressure, it may be extended into the region of negative pressure, the negative portion then representing the pressure arising from the molecular attraction, and the internal heat of vaporisation appearing always as a pressure-volume area below the line of zero pressure; at the critical temperature no area results, (V − *v*) becoming zero. The negative pressures found are the average internal pressures during the given change in volume, excepting at the critical temperature, at which there is no change in volume, so that the "average" negative pressure should represent the true internal pressure at this volume.

The calculated internal pressures have been plotted against the volumes, and it is found that at the critical temperature this internal pressure is equal to the internal pressure obtained from the thermodynamical equation within the limit of experimental error. It is then shown that the internal attractive energy given out by a substance on contraction from an infinite volume to volume *v* or density *d* can be represented graphically by the area between the V axis, the above curve and the ordinate at the volume *v*. The value of the internal negative pressure at the critical temperature has been arrived at by four different methods, which give concordant results. T. H. P.

771. *Glass Research*. (Chem. News, 111. pp. 187–189, April 16, 1915.)—Results are given of investigations conducted by a Committee appointed by the Institute of Chemistry with a view to ascertain suitable formulæ for glasses for various purposes. Such formulæ are given for: (1) Soft glasses, suitable for ordinary chemical laboratory ware; (2) Resistant glass for pharmaceutical purposes, ampoules, etc.; (3) Combustion tubing; (4) Miners' lamp-glasses; (5) Resistance glass, similar to Jena glass, and (6) Soft soda-glasses suitable for tubing and X-ray bulbs. The glasses corresponding with the formulæ given have been submitted to rigorous tests. T. H. P.

772. *The Allotropy of Potassium*. I. **E. Cohen** and **S. Wolff**. (K. Akad. Amsterdam, Proc. 17. pp. 1115–1118, March 26, 1915.)—The authors, in commencing an investigation of whether potassium, as hitherto known, is a metastable system, in consequence of the simultaneous presence of two or more allotropic forms of the metal, consider the data which are already to be found in the literature of the subject. From an examination, more especially of the dilatometric measurements by E. Hagen, dating from 1888, the authors conclude that potassium can undergo transformation into a second modification (β-potassium), and that the metal, as it has hitherto been known, is, at the ordinary temperatures, a metastable system, in consequence of the presence of both forms at the same time. The authors are now undertaking a more accurate experimental investigation of the question. A. F.

773. *Flame Reactions*. IV. *Salts in Oxygen and Chlorine Flames*. **W. D. Bancroft** and **H. B. Weiser**. (J. Phys. Chem. 19. pp. 310–330, April, 1915.)—A simple modification of the Gouy sprayer and apparatus for burning hydrogen in chlorine, and chlorine in hydrogen, have been devised. Salts of lithium, potassium, and sodium give two distinct spectra in the Bunsen flame, one a continuous and the other a line spectrum. Introduction of hydrogen chloride into the flame diminishes the intensity of the line spectra of the alkali metals. With hydrogen burning in chlorine the line spectra disappear completely, and the D lines are obtained faintly when sodium chloride is introduced into a flame of chlorine burning in hydrogen. The blue luminescence of sodium is obtained without the yellow: when sodium salts are introduced into the flame of hydrogen burning in chlorine; or, when metallic sodium burns slowly in oxygen, chlorine, or bromine; or, when a sodium salt is fused; or, when kathode rays act on sodium chloride, or anode rays previously act on the salt; or, when the coloured residue, obtained by the

action of anode or kathode rays on sodium chloride, is heated; or, when the sodium chloride is precipitated rapidly from aqueous solution by hydrochloric acid or alcohol. The yellow luminescence, together with the fainter blue luminescence, is obtained: when a sodium salt is introduced into the Bunsen flame; or, when sodium burns rapidly in oxygen, chlorine, or bromine; or, when canal rays act on sodium chloride. It is stated that the yellow luminescence is obtained when sodium vapour is heated, but it is difficult to be certain that no burning takes place under these conditions. The blue luminescence is due to the reaction from sodium ion to undissociated sodium salt, and the yellow to some stage in the reaction from sodium vapour to the sodium ion. Since sodium vapour is coloured, it will give a thermal luminescence, but it is uncertain whether the concentration of the sodium vapour in the Bunsen flame is sufficiently high for this thermal luminescence to be an important factor. In so far as solid sodium salts may be present in the Bunsen flame, they would theoretically give thermal luminescence.

To account for the absence of the yellow luminescence when sodium burns slowly, it is postulated that the light intensity for this reaction is very slight when the velocity is low. The diminished intensity of the line spectra in the hydrogen-chlorine flame or in the Bunsen flame to which hydrogen chloride has been added, is due to the decreased dissociation of the salts; the salts dissociate almost entirely to ions and only slightly or not at all to free metal. In the case of the line spectrum, the reacting substance is the electrically neutralised vapour of the metal, so that there is no migration under electrical stress; with the continuous spectrum, as Lenard found, the opposite is the case, the reacting substance here being the positively-charged ion of the metal. T. H. P.

774. *Vapour-pressure Lines of the System, Phosphorus.* III. **A. Smits** and **S. C. Bokhorst.** (K. Akad. Amsterdam, Proc. 17. pp. 962-973, Feb. 27, 1915.)—In order to obtain definite information concerning the supposed transition point with violet phosphorus, the vapour-pressure curve has been investigated [see Abs. 825 (1915)]. Various samples of violet phosphorus were prepared at different temperatures, and were extracted with carbon disulphide to remove white phosphorus and treated with ammonia to get rid of any phosphoric acid. The measurements, made between about 290° and 480°, show that the vapour-pressure curve is lower, the higher the temperature of preparation of the sample. Apparently the establishment of the internal equilibrium proceeds so slowly that it is not effected during the determination of the vapour pressure; such establishment is most complete for the highest temperature of preparation. The vapour pressure-temperature curve is perfectly regular and the discontinuity previously found at 450° is due to the presence of a small proportion of white phosphorus. The triple-point temperature is ascertained to be 589·5°, and from the fact that, for molten violet phosphorus, T log P is a rectilinear function of T, it follows that the triple-point pressure is $43{\cdot}1 \pm 0{\cdot}5$ atmos. According to the theory of allotropy, every phase of an allotropic substance exhibits the phenomenon of molecular allotropy, so that violet phosphorus should correspond with an internal equilibrium, this being generally dependent on temperature and pressure. Experiment proves the accuracy of this view, and shows that the internal equilibrium exists between at least two pseudo-components differing greatly in volatility.

Only one stable solid modification of phosphorus exists, and to this the name violet phosphorus is given, although, when finely ground, it assumes a red colour; white phosphorus represents a metastable form and red phosphorus an intermediate metastable modification which is not in internal equilibrium. These results are in contradiction of Cohen and Olie's views (Zeitschr. Phys. Chem., 71. p. 1, 1900).

Bridgman [Abs. 1745 (1914)] has shown that white phosphorus exhibits a transition-point at —80°, where the ordinary white variety assumes a hexagonal form; phosphorus therefore possesses a metastable transition-point. It remains undecided if the black phosphorus described by this author is a new modification. T. H. P.

775. *Further Particulars concerning the System, Phosphorus.* **A. Smits** and **S. C. Bokhorst.** (K. Akad. Amsterdam, Proc. 17. pp. 978–982, Feb. 27, 1915.)—For both liquid and solid violet phosphorus, T log P is a rectilinear function of T and the quantity Q of the equation $d \log p/dT = Q/RT$ may therefore be regarded as a constant. It is found graphically from the T log P line for the solid form that C has the value 18·889, which is about double the value for the liquid violet phosphorus. For Q/R the extreme values found are 13,006 and 13,079, the mean being 13,050, and the values calculated for the pressures at different temperatures are in good agreement with the experimental values. The above mean value for Q/R gives the very high number 25·839 K. cals. for the molecular heat of sublimation, and since the heat of evaporation of liquid violet phosphorus has been found to be 9·962 kg. cals., the molecular heat of fusion is 15·877 kg. cals. These high values indicate that the heating effect is mainly a chemical effect. Assuming that this is entirely the case and knowing that $P_{\text{white}} \longrightarrow P_{\text{violet}} + 4{\cdot}4$ gm. cals. (per gm.-atom), a chemical heat of 4 × 4·4 gm. cals. is included in the molecular heat of sublimation, so that $25{\cdot}8 - 17{\cdot}6 = 8{\cdot}2$ kg. cals. represents the physical heat.

Wahl (Medd. fran Finska Kemistsamfundet, 1913, 3) gives 695° as the critical temperature of liquid violet phosphorus and this value, together with the T log P line, gives 83·56 atmos. for the critical pressure. From van der Waals' relation, $b = T_K/8{\cdot}273P_K$, $b$ is found to have the value 0·005804, and, on the assumption that $b$ is an additive quantity in, *e.g.* $PH_3$, the phosphorus molecule is calculated to contain 4·26 atoms at the critical temperature and pressure of liquid violet phosphorus.

The factor $f$ of van der Waals' vapour-tension formula,

$$-\log(p/p_K) = f(T_K/T - 1),$$

is equal to 4·221, which differs greatly from the value, 3, for substances having molecules of the same size in the liquid and vaporous states. Consequently, for violet phosphorus, the average sizes of the molecules in the coexisting vapour and liquid are different. T. H. P.

776. *Sodium Amalgams: Specific Volumes and Electrical Conductivities.* **E. Vanstone.** (Chem. Soc. J., Trans. 105. pp. 2617–2628, Nov., 1914.)—The author has measured the conductivity of liquid sodium amalgams at the temperatures 107° and 183°. The amalgams were kept under paraffin, and drawn up into a capillary spiral having Pt terminals sealed into the glass at convenient points. The spiral was open at the lower end, and fitted with a glass tap at the top. It was connected to a hydrogen apparatus, and before allowing any amalgam to enter it was dried and filled with hydrogen. The capillary was 1 mm. in diam., and the distance between the Pt terminals about 1 m. when unwound. It was calibrated by finding the resistance

of mercury filling the spiral. The results are given below. The concentrations are expressed in atomic percentages of sodium; the resistances refer to a spiral in which the resistance of mercury at 17° is 1 ohm.

ELECTRICAL CONDUCTIVITIES OF LIQUID AMALGAMS.

| Concentration. | Resistance at 107°. | Conductivity. | Resistance (133°). | Conductivity. | Temperature-coefficient. |
|---|---|---|---|---|---|
| 100 | 0·2285<br>0·2286<br>0·2266<br>0·2260 | 4·397 | 0·2455<br>0·2449<br>0·2477 | 4·065 | 0·01276 |
| 95·36 | 0·4225 | 2·366 | 0·4334 | 2·307 | 0·00226 |
| 93·64 | 0·5835 | 1·714 | — | — | — |
| 89·88 | 0·7749 | 1·2905 | 0·8139 | 1·2286 | 0·00288 |
| 85·60 | 0·9796 | 1·0208 | 1·0133 | 0·9868 | 0·00130 |
| 80·50 | 1·1569 | 0·8643 | 1·1627 | 0·8600 | 0·00016 |
| 77·89 | 1·2124 | 0·8248 | 1·2248 | 0·8164 | 0·00032 |
| 75·31 | 1·2532 | 0·7979 | 1·2584 | 0·7946 | 0·00018 |
| 71·74 | — | — | 1·3087 | 0·7641 | — |
| 70·02 | 1·2921 | 0·7739 | 1·3096 | 0·7635 | 0·00040 |
| 68·08 | 1·2968 | 0·7711 | 1·3208 | 0·7571 | 0·00054 |

The fall in conductivity is most marked from 100 to 85 atoms per cent. of Na; the latter concentration is that of the eutectic point in the thermal diagram. The temperature coefficient falls with extreme rapidity as we pass from pure sodium to alloys containing 5 to 10 atoms per cent. of Hg. The temperature coefficient-composition curve does not give any indication of the formation of compounds. The conclusion to be drawn is that the intermetallic compounds which are formed are completely dissociated in the liquid condition. The author also concludes that the freezing-point is the property which is of most value in determining the constitution of the alloys. [See also Abs. 626 (1912).] A. F.

**777.** *Accidental Deviations of Density and Opalescence at the Critical Point of a Single Substance.* **L. S. Ornstein** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 17. pp. 793–806, Dec. 24, 1914.)—The paper is a mathematical one, and the following conclusions are obtained:—(1) The known formulæ of critical opalescence give an infinite value at the critical point. Efforts to escape from this difficulty have furnished formulæ for the deviations of density with a dependence upon the volume, at variance with the assumed mutual independence of the elements of volume. (2) In order to obtain formulæ applicable in the critical point, it is found necessary to take into account the mutual influence of the elements of volume, it being shown that near the critical point this influence is sensible for distances large in comparison with the radius of the sphere of attraction. (3) Two functions are introduced, one relating to the direct interaction of molecules, the other to the mutual influence of two elements of volume. An integral equation gives the relation between the two functions. (4) Corrected values are found for the mean deviations, and in the formula of opalescence a correction is introduced. The latter depends upon the sphere of attraction which can thus be calculated from observations. (5) Further, it is shown that the same results may be arrived at by taking into account the mutual influence of the elements of volume in the deductions of statistical mechanics. A. F.

778. *Theory of Equations of State.* **M. B. Wagner.** (Ann. d. Physik, 45. 8. pp. 1169–1202, Dec. 8, 1914. Part of Dissertation, Leipzig.)—The pressure which a substance exerts on unit surface of its enveloping wall is taken to be the sum of the repulsive forces of all the molecules the centres of which lie perpendicularly over this surface. But if the wall is regarded as the seat of an attractive force influencing the molecules—such a mutual action does undoubtedly exist—the pressure $p$ experienced by unit area of the wall must then be defined as the difference between the repulsive forces of the molecules and the attractive forces of the wall, $p = r - a$. The forces $r$ depend both on the composition of the wall and on the nature of the contained substance. It would appear that the equation of state of the wall would be a function of its nature, but thermodynamic considerations disprove this.

Two new methods are described for deriving equations of state: (1) From the properties of the containing wall, and (2) from considerations of continuity. The equations so deduced are shown to be independent of the physical properties of the wall. The methods employed by van der Waals and by Boltzmann in arriving at the attractive forces between the molecules are discussed. T. H. P.

779. *Conductivity of extremely Dilute Acid and Alkali Solutions.* **H. H. Paine** and **G. T. R. Evans.** (Cambridge Phil. Soc., Proc. 18. 1. pp. 1–18, Oct., 1914.)—It is well known that the conductivity of acids and alkalies falls off in dilute solutions in a way that does not occur with neutral salts. If the impurity to which ordinary distilled water owes its slight conducting power were an alkaline hydroxide the *specific* conductivity plotted against concentration would give a straight line turning abruptly parallel to the axis of concentration at the point where the acid and the alkaline impurity neutralised one another exactly. If the impurity were a carbonate the curve would break away from the line more gradually. The concentration at which the linear law breaks down should depend on the quantity of impurity until a point is reached at which similar effects were produced by the natural ionisation of water. These ideas have been verified by experiment and all the indications point to the chief impurity being a carbonate. Analogous phenomena are observed with alkalies which also appear to be neutralised in dilute solutions by impurities present in the water; the chief impurity is therefore probably ammonium carbonate derived from the air. T. M. L.

780. *Free Energy of the Various Forms of Elementary Sulphur.* **G. N. Lewis** and **M. Randall.** (Am. Chem. Soc., J. 36. pp. 2468–2475, Dec., 1914.)—The following table gives the free energy of formation of the forms of sulphur considered in this paper:—

| Substance. | $F^{o}$ 298. | Substance. | $F^{o}$ 298. |
|---|---|---|---|
| $S_R$ | 0 | $S_{\gamma,\mu}$ | $-0{\cdot}8$ |
| $S_M$ | 17·5 | $S_2$ | 17,600 |
| $S_\lambda$ | 94 | | |

T. M. L.

781. *Coefficient of Internal Friction of Solutions of Gum Dammar in Turpentine, in dependence on the Temperature and Concentration.* **J. N. Reznikov.** (Russian Physico-Chem. Soc., J. 46. 2. pp. 75–80, 1914.)—By means of the apparatus described by Alfimov and Weinberg [Abs. 385 (1915)], the author has prepared solutions of gum dammar in turpentine varying in concentration from 30 to 95 %. The density of these solutions at 21° increases from 0·8565 to 1·2144 as the content of gum dammar rises from 0 to 85 %;

the more concentrated solutions are so viscous, even at 100°, and retain air-bubbles so tenaciously that their densities could not be measured. The coefficients of internal friction of the solutions were determined from the time of flow, 7 metal and glass tubes of different diams. being employed, the results being calculated by means of Poiseuille's formula: $\eta = \pi P R^4 t\delta/8qL$, where P is the pressure of the column of liquid, L the length of the tube, R the radius of the tube, $t$ the time of flow, and $q$ the weight and $q/\delta$ the volume of the liquid which flows from the tube. The value of the temperature coefficient, determined by means of the formua, $\eta_{t_1} = a^{t_2-t_1} . \eta_{t_2}$, varies from 1·017 for pure turpentine to 1·060, 1·096 and 1·275 for the solutions containing 50, 80, and 75 % of gum dammar respectively. The curve connecting the coefficient of internal friction with the percentage of gum dammar present is logarithmic and corresponds closely with that obtained by Glaser [Abs. 1126 (1907)] for mixtures of turpentine and colophony. For pure oil of turpentine the author finds the values 0·8565 and 1380 for the density and $\eta \times 10^{-5}$ at 22·2°; Glaser gave 0·87 and 1418 and Garvanoff (Akad. Wiss. Wien, Ber. 103. 2a. p. 877, 1894) 0·8598 and 1327. T. H. P.

782. *Heat of Formation from E.M.F. Measurements.* **L[uise] Wolff.** (Zeitschr. Elektrochem. 20. pp. 19–22, 1914.)—When the e.m.f. and temperature coefficient of the AgCl-cell are measured, the formula of Helmholtz yields for the heat of formation of AgCl the value 30,612 cals. This value does not agree with Koref and Braune; but the reactions at the chlorine electrode are complex, unless the chlorine pressure is reduced after Lewis and Rupert by feeding the Pt electrodes with a mixture of chlorine and dry air. The results confirm Pollitzer against E. Cohen. The calomel cell gave similarly for the heat of formation of Hg, Cl, 31,837 cals. (63,674 for $Hg_2$, $Cl_2$) in a combined cell the heat of reaction of $2Ag + Hg_2Cl_2 = 2Hg + 2AgCl$ was —2 × 1324. J. Thomsen's value for AgCl would hence be too small, and the value for $Hg_2Cl_2$ too large. H. B.

783. *Measurement of the Freezing-point Depression of Dilute Solutions.* **L. H. Adams.** (Am. Chem. Soc., J. 37. pp. 481–496, March, 1915.)—The author has carried out accurate determinations of the freezing-point of dilute solutions of mannitol, potassium nitrate, and potassium chloride, the temperature being measured directly, with an uncertainty of not more than 0·0001 deg., by means of a 50-junction copper-constantan differential thermo-element. For the attainment of this degree of accuracy it is necessary to have a stationary equilibrium, and this was secured by a thorough mixing of the solution with a large quantity of ice in a vacuum-jacketed vessel, completely surrounded by melting ice. The concentration of the equilibrium solution was determined by a zero method in which a Zeiss interferometer was used as a means of comparison. The sensitiveness of this method is about 2 parts of solute per million of water.

From the freezing-point depressions the degree of ionisation of potassium nitrate and chloride was calculated. In the case of the former the difference between the ionisation calculated from the freezing-point and from the conductivity, is no greater than the experimental error at all concentrations up to 0·02 molar. At the higher concentrations the values diverge. In the case of potassium chloride the agreement between the several values of the ionisation is all that could be desired. A. F.

**784.** *Calcium Amalgams.* **L. Cambi and G. Speroni.** (Accad. Lincei, Atti, 23. pp. 599–605, Jan. 10, 1915.)—The authors have subjected these amalgams to thermal analysis. Those with less than 88 atomic per cent. of Ca contain the compound $CaHg_4$, which melts and decomposes at 266°. At higher temperatures, separation of the compound $CaHg_3$ probably occurs. Mixtures with more than 14 atomic per cent. of Ca do not melt completely at the ordinary temperature, but boil at 877°. No confirmation has yet been obtained of the existence of compounds with higher proportions of mercury such as have been described by various investigators.

T. H. P.

**785.** *Coefficient of Diffusion in Dilute Solutions.* **B. W. Clack.** (Phys. Soc., Proc. 27. pp. 56–69; Disc., 69, Dec. 15, 1914.)—Describes modifications made in the apparatus previously described [Abs. 928 (1909) and Ibid. 24, p. 40, 1911] to determine the value of the coefficient of diffusion of salts through water, by means of which the steady state is hastened and results obtained more quickly.

The single wide tube previously employed is replaced by a battery of shorter and narrower tubes. The error due to end-correction is investigated and results are given for the salts KCl, $KNO_3$ and NaCl for various concentrations down to very dilute solutions. AUTHOR.

**786.** *Viscosity of the Vapour of Iodine.* **A. O. Rankine.** (Roy. Soc., Proc. 91. pp. 201–208, March 1, 1915.)—Values are tabulated for the approximate viscosity as calculated and also for the corrected viscosity, in which the variation of dimensions of the capillary with temperature and for the slipping of the gas over its internal walls, are allowed for. The corrected values range from 1·843 at 124° C. to 2·401 at 247° C. [See Abs. 360 (1914).]

L. H. W.

**787.** *Dissociation of Hydrogen into Atoms.* II. *Calculation of the Degree of Dissociation and the Heat of Formation.* **I. Langmuir.** (Am. Chem. Soc., J. 37. pp. 417–458, March, 1915.)—Previous calculations of the degree of dissociation of hydrogen from the results of experiments on the heat losses from tungsten wires in hydrogen [see Abs. 1474 (1912), 1932 (1914)] are in disagreement with Bjerrum's determinations of the specific heat of hydrogen by the explosion method. The weak point in the calculation is a somewhat arbitrary assumption regarding the diffusion coefficient of atomic hydrogen through ordinary hydrogen. That the abnormal thermal conductivity of hydrogen at high temperatures is due to dissociation is indicated by the observation that, when the gas at low pressures comes into contact with metallic wires at temperatures above 1300° K. part of the hydrogen is converted into an active modification which remains adsorbed on glass surfaces for a long time. This active hydrogen reacts at room temperature with oxygen and many reducible substances and dissolves in metals such as Pt; it appears to be in the atomic condition.

More accurate measurements have now been made of the thermal losses from a tungsten wire at temperatures ranging from 800° to 3500° K. and at pressures of hydrogen (or nitrogen) from 0·01 mm. to atmospheric pressure. At temperatures below that of dissociation the loss of heat diminishes steadily as the pressure is lowered. Convection currents play an important part only when the pressure exceeds 200 mm., the decrease in the heat loss at lower pressures being due to the temperature discontinuity. The theory of this effect is developed for the case of small wires at very high temperatures, the calculated results being in good agreement with the experimental ones. The normal thermal conductivity is separated from the abnormal effect due to dissociation and the amounts of heat carried from the wire by the dissociation are calculated for various temperatures and pressures.

The following theory of the observed phenomena is proposed. The dissociation of the hydrogen does not occur in the space round the wire, and is not due to the impact of the gas molecules against its surface, but takes place only among the hydrogen molecules which have been absorbed [? dissolved] by the metal of the wire. Within the metal the reaction is so rapid that equilibrium may be always assumed, but the equilibrium constant may differ widely from that in the gaseous phase. It is assumed that there is no "adsorption film" on the surface of the wire through which the hydrogen has to diffuse, but that the absorption takes place by the collision of the molecules (or atoms) with the surface. It is supposed that a certain fraction $\alpha_2$ of all the impinging hydrogen molecules is absorbed, the fraction $1 - \alpha_2$ being reflected, and that the fraction $\alpha_1$ of all the impinging hydrogen atoms is absorbed. In general, the partial pressures of atomic hydrogen in the gas immediately surrounding the wire will not be that corresponding with the equilibrium at the temperature of the wire; the difference may be regarded as a "drop in concentration" at the surface of the wire strictly analogous to Smoluchowski's "temperature drop" in the case of heat conduction and to Kundt and Warburg's "slip" in the case of experiments on the viscosity of gases.

From this theory it is possible, by thermodynamic reasoning, to deduce the relation—

$$K = \frac{(W/q)^2 (P/D + 1/\alpha_1)^2}{P - (W/q)(P/D + 1/\alpha_2)},$$

where K is the dissociation constant in the gas phase, W the heat carried from the wire by dissociation, $q$ the heat of reaction, and D is the diffusion coefficient. With suitable values of K, $q$, D, $\alpha_1$ and $\alpha_2$, the calculated and experimental values of W agree well at all temperatures and pressures. The coefficients $\alpha_1$ and $\alpha_2$ are found to be constant and equal to 1 and 0·68 respectively. T. H. P.

788. *Formation of a Badly Conducting Film on Copper Anodes in Copper Cyanide Solutions.* **W. L. Miller.** (Am. Electrochem. Soc., Trans. 26. pp. 63–66, 1914.)—In some experiments with a copper cyanide bath, using strips of copper 9 × 8 cm. as electrodes, the 110-volt lighting circuit was used as the source of current, a 32-c.p. carbon-filament lamp being used as resistance in the circuit. The lamp, within a minute's time, burned dim, and the p.d. across the electrodes became 45 volts. The anode was found to be coated with a yellowish-green, adherent deposit, which was proved to be the cause of the drop in current and jump in the voltage. Experiments with a number of different copper cyanide baths, made according to varying recipes, showed that there was no connection between the current density at which the voltage jumps occurred and the amount of "free cyanide" in the bath. The explanation of the observed phenomena was found to be as follows: With high current densities the concentration of copper in the solution at the anode surface, owing to the fact that diffusion and convection do not work rapidly enough, becomes so great that a precipitate is formed, which gives the adherent coating on the anode. In support of this explanation

it was found that solutions in which a small amount of additional copper salt produced a precipitate gave the voltage jump with a low current density, and *vice versâ*. To permit the use of a high anodic current density it is therefore necessary to add cyanide, ammonia, or any other substance that holds copper in solution. T. S. P.

789. *Electromotive Force of Calcium Amalgams.* **L. Cambi.** (Accad. Lincei, Atti, 23. pp. 606–611, Jan. 10, 1915.)—The author has measured the e.m.f. of calcium amalgams in methyl alcoholic solutions of calcium chloride cooled to −80°, the solutions being kept in an atmosphere of pure, dry hydrogen. These amalgams exhibit anomalies similar to those observed with sodium amalgams by Haber and Sack [Abs. 176 (1903)], the values of the e.m.f. showing oscillations of about 0·08 volt: those containing more than 10 atomic per cent. of Ca give, however, almost or quite constant values. At the composition corresponding with $CaHg_4$ a sudden increase of about 0·2 volt occurs and in the region 10–15 atomic per cent. of Ca, the potential shows another, less sharp variation of about 0·14 volt, this indicating the formation of another compound, possibly $CaHg_3$. [Compare Abs. 784 (1915).]

T. H. P.

790. *Influence of Organic Bases on the Potential of the Hydrogen Electrode.* **A. Mazzucchelli.** (Accad. Lincei, Atti, 24. pp. 139–143, Jan. 30, 1915.)—The author has examined the effect on the hydrogen electrode of the addition of small proportions (0·3–0·7 per cent.) of quinine and cinchonine bisulphates, of the sulphates of brucine, veratrine, coniine, hydrastine, quinoline, lutidine, dimethylaniline, phenylhydrazine, and of saponin, gelatin, and soluble starch [compare next Abs.]. The action of organic bases on the hydrogen electrode is similar to that on zinc. The extent of the effect varies, but of the more simple bases, those which are most active with zinc, namely quinoline and dimethylaniline, are also most active towards the hydrogen electrode. The action is most marked at first and diminishes more or less rapidly later. The colloidal substances, starch and gelatin, and also saponin, which exhibits the power of concentrating at the free surface of the liquid, are without effect. The action of the bases is not easy to explain, since in this case electrolytic decomposition of the salts with liberation of the bases is out of the question. T. H. P.

791. *Kathodic Deposition of Metals in Presence of Organic Bases.* I. *Zinc.* **A. Mazzucchelli.** (Accad. Lincei, Atti, 23. pp. 503–508, Dec. 13, 1914.)—The author has investigated the effect of small proportions of salts of quinine, cinchonine, quinoline, dimethylaniline, α-naphthylamine, lutidine, aniline, pyridine, and gelatin on the electrolytic deposition of zinc from a solution containing zinc and ammonium sulphates, a pure zinc anode and a brass kathode being used. With very small amounts of these additions and when the current density is low, a homogeneous, uniform, fine-grained deposit is obtained. When the amount of the added substance or the current density is increased, the zinc separates irregularly in warty masses. The first uniform deposit invariably dissolves only slowly in hydrochloric acid. It seems that the organic substance present in the neighbourhood of the kathode is absorbed by the metallic granules separating initially in a state of high dispersion and renders the deposit fine-grained. At a later stage, the organic compound tends to coat the kathode with a more or less impermeable varnish, which determines the passivity. At certain points

of the kathode which are accidentally favoured, deposition may continue at an increased current density, the crystalline warty masses being thus formed. The experiments made up to the present indicate that the kathodic process—the deposition of the zinc—is influenced more than that at the anode—the dissolution. It may therefore be supposed that, in a solution of one of these added substances, a Zn electrode would behave unipolarly, as is the case with Cu in potassium cyanide solution, and would dissolve irreversibly. It is indeed found that passage of an alternating current between two Zn electrodes immersed in a 0·05 per cent. quinoline sulphate solution is accompanied by continual evolution of hydrogen, and further, that the deposition potential of Zn exhibits supertension in presence of one of the above bases. Possibly such addition of a base may result in the electrolytic deposition of alloys which are not formed from the pure solutions. T. H. P.

792. *Galvanic Cell which Reverses its Polarity when Illuminated.* **A. A. Campbell Swinton.** (Phys. Soc., Proc. 27. pp. 186–188, April, 1915.)—If two plates—one of zinc and the other of tinned copper coated on one surface with Se and varnished with enamel over the remainder of its surface—are immersed in tap-water, the electric current through a galvanometer connected to the plates shows that in the dark the zinc is electro-positive to the Se, while the result of light falling on the Se is to increase the effect. If, however, instead of zinc, carbon or copper is employed for the non-coated plate, the Se is electro-positive to the carbon or copper in the dark, but it immediately becomes electro-negative to carbon or copper on being illuminated, this being easily shown by the deflections of the galvanometer in contrary directions as the light is turned on and off. T. S. P.

793. *Revision of the Atomic Weight of Cadmium.* III. *Electrolytic Estimation of Cadmium in Cadmium Chloride.* **G. P. Baxter** and **M. L. Hartmann.** (Am. Chem. Soc., J. 37. pp. 113–131, Jan., 1915.)—Hulett and his collaborators have obtained concordant results indicating that the atomic weight of Cd is 112·3, which is lower than the value obtained by Baxter and his co-workers, namely 112·4. The authors have consequently carried out a fresh series of determinations of the atomic weight, the percentage of Cd in cadmium chloride being estimated by electrolysing the solution, using a mercury kathode, the amalgam formed being subsequently weighed. The electrolytic cell used was constructed of glass, both the electrodes being permanently sealed into their positions; the anode was of Pt. The cadmium chloride used was obtained from the bromide, which is readily obtained pure by recrystallisation, by heating it in a current of chlorine.

The percentage of Cd in anhydrous cadmium chloride was found to be 61·819, giving a value of 112·417(Cl = 35·457) for the atomic weight of cadmium, which is in perfect agreement with the results hitherto obtained by Baxter and his collaborators. T. S. P.

# SCIENCE ABSTRACTS.

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